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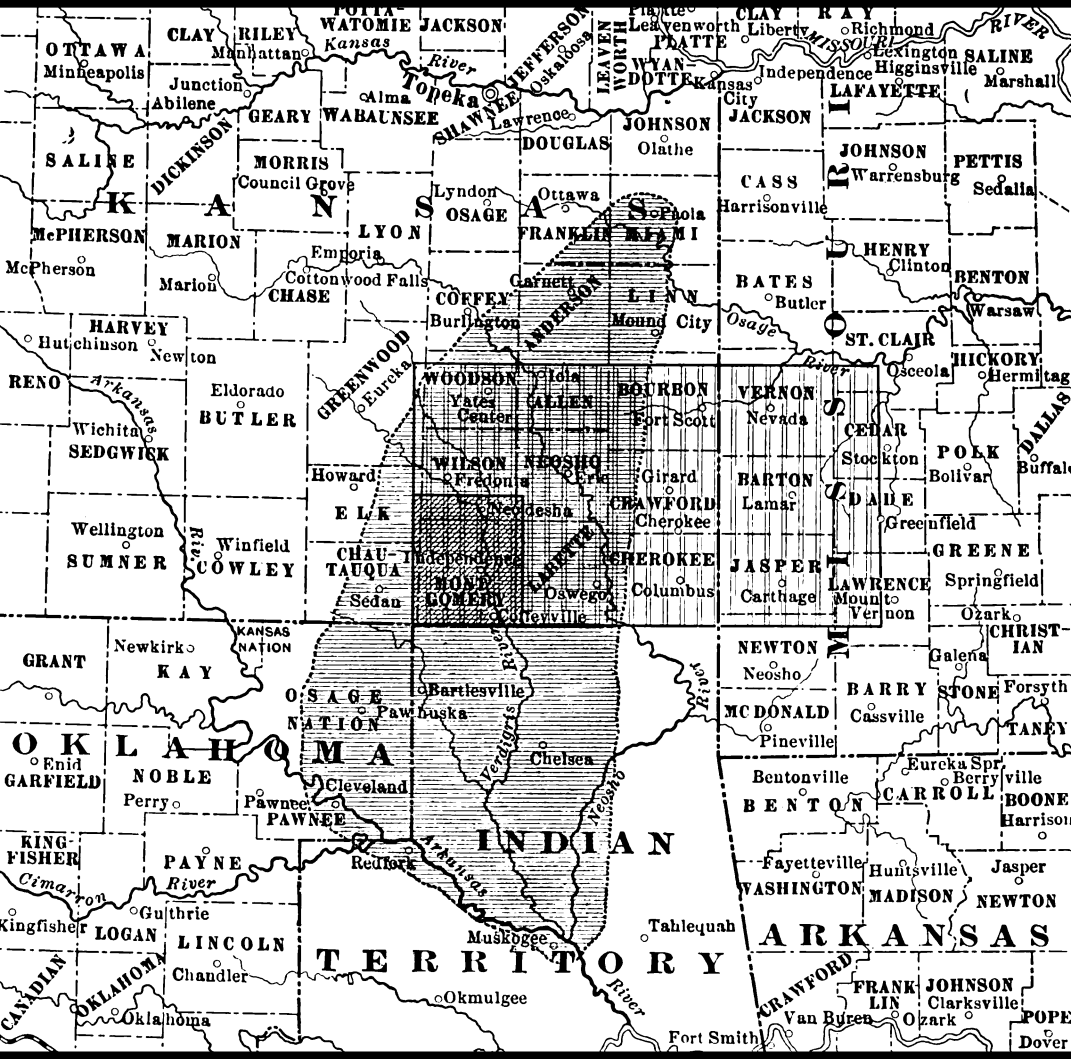

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CHARLES D. WALCOTT, DIRECTOR

ECONOMIC GEOLOGY

OF THE

INDEPENDENCE QUADRANGLE, KANSAS

BY

FRANK C. SCHRADER AND ERASMUS HAWORTH

WASHINGTON

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1906

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ECONOMIC GEOLOGY OF THE INDEPENDENCE QUADRANGLE, KANSAS.

By FRANK C. SCHRADER and ERASMUS HAWORTH.

INTRODUCTION.

LOCATION OF THE QUADRANGLE.

The Independence quadrangle is a rectangular area of about 950 square miles, situated in southeastern Kansas, adjacent to Indian Territory (fig. 1), its eastern limit being about 47 miles west of the Kansas-Missouri line. It forms an important part of the well-known Kansas–Indian Territory oil and gas fields, which have an area of nearly 11,000 square miles, extending from Paola, in eastern Kansas, southwestward a distance of 200 miles to Muscogee, Ind. T., and Cleveland, Okla. (fig. 1). The quadrangle is bounded by meridians 95° 30′ and 96° west longitude and parallels 37° and 37° 30′ north latitude. It includes Montgomery County, the southern third of Wilson County, and portions of other counties adjoining these two on the east and the west. The chief towns are Independence, Coffeyville, Cherryvale, Neodesha, Caney, and Elk. The growth of these towns has been greatly stimulated during the last few years by the finding of oil and gas.

GENERAL STATEMENT.

The aim of this paper is to present the substance of what is known concerning the distribution, occurrence, and development of the oil and gas of the quadrangle, and to note briefly the more important industries growing out of these natural resources or depending on them within the territory considered.

The geologic field work on which the paper is based was done during the summer of 1904 and is essentially a continuation of that begun by the Survey in 1903 on the diagonally adjacent Iola quadrangle. Charge of the work was intrusted to Mr. F. C. Schrader, who was assisted by Prof. Erasmus Haworth and Messrs. Otto Veatch and George L. Metcalf.

Acknowledgments for additional assistance, courtesies, and information are due to the Prairie Oil and Gas Company, to the Edgar and the Granby zinc-smelting companies, and to the University Geological Survey of Kansas and several of its members, who, under the direction of Professor Haworth, have in previous years made a study

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of this and adjacent parts of the field, and whose labors constitute the basis of much of the geology of the eastern part of the area shown on the map forming Pl. II. Prof. E. C. Murphy, of the United States Geological Survey, has contributed valuable information on the hydrography of the region.

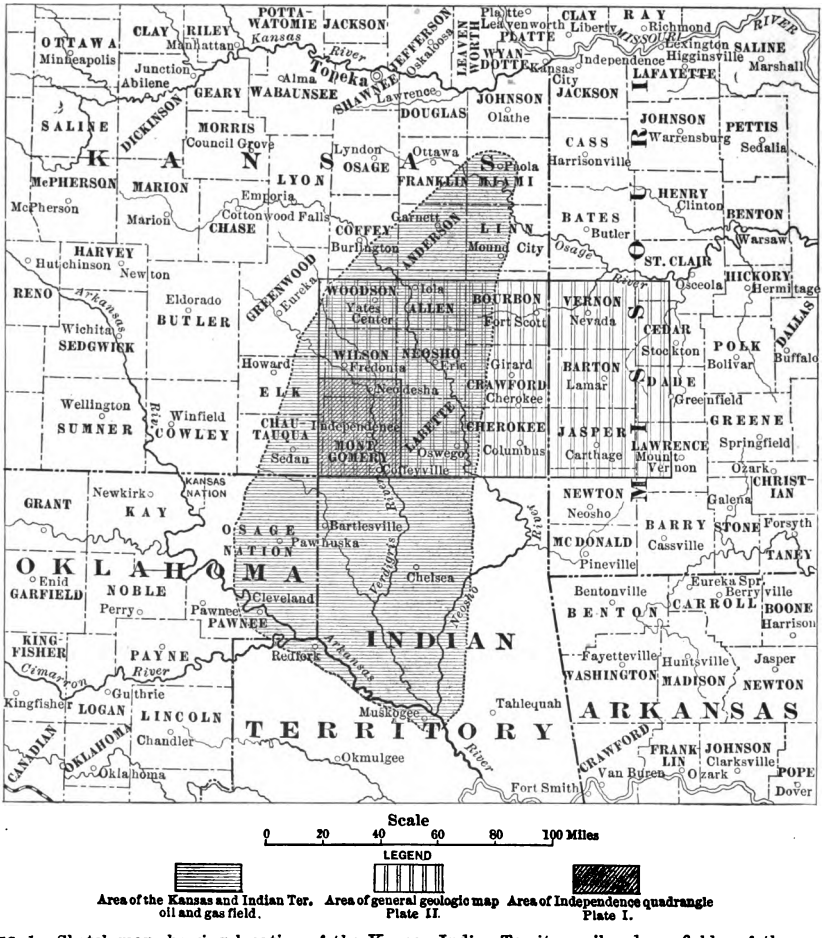

FIG. 1.—Sketch map showing location of the Kansas-Indian Territory oil and gas fields; of the area covered by the geologic map, Pl. II; and of the Independence quadrangle, Pl. I.

GEOLOGY.

SURFACE FEATURES.

The surface features of the quadrangle are essentially those of the prairie-plains region, of which the eastern third of Kansas forms a part.

Except for fringes of forest that line the larger streams and portions of the sandstone hills occupied by black-jack oak, the region is essentially treeless. The topography is of the indistinct terrace and escarp-

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ment type and the surface varies from nearly flat to hilly or even rugged along the western or dip sides of the main valleys, where many of the hills present steep scarps 200 feet or more in height. The hills are nearly flat-topped and are locally known as mounds, especially where they occur as outliers separated from the main wall of the valley.

The vertical range between the tops of the highest hills and the floors of the lowest valleys is about 440 feet. The lowest point in the quadrangle, 690 feet in altitude, is in the southeast corner, where Verdigris River crosses the Kansas-Indian Territory line; this is also the lowest point in the State. The highest point is in the northwest corner, on the Dunham ranch, where the altitude is 1,130 feet. The average altitude somewhat exceeds 900 feet.

The master stream is Verdigris River, to which all the drainage of the quadrangle is tributary. The Verdigris and its principal tributaries, Fall and Elk rivers, meander through flat-bottomed infilled valleys from 1 mile to 2 miles in width.

The surface relief has been developed by erosion acting on alternating hard and soft beds of limestone, sandstone, and shale, which dip, in general, a little north of west at the average rate of about 15 feet per mile. In passing diagonally across the quadrangle from southeast to northwest—from Coffeyville to Buxton, for example—one not only reaches higher altitudes, but also crosses successively higher geologic horizons.

In this paper the rocks of the quadrangle have been grouped into seven formations. They constitute about one-third of the Coal Measures of Kansas and aggregate about 1,000 feet in thickness, of which considerably more than three-fourths is shale and sandstone and less than one-fourth limestone. The limestones strongly resemble one another and can be differentiated only by a close study of their detailed characteristics. They are mostly fine grained, crystalline, or semicrystalline. The shales vary from argillaceous to arenaceous and are usually bituminous. Some of them, and particularly the nodules which they contain, give off a pronounced odor that suggests oil.

With one exception the rocks of the quadrangle belong to the Pennsylvanian series, commonly known as the Coal Measures, and extend downward about 1,000 feet below the lowest formation exposed at the surface. The formations contained in the lower part of the section outcrop east of the quadrangle, the lowest appearing about 30 miles distant, as is shown in the accompanying map (Pl. II). This lower portion of the section, though not exposed at the surface within the limits of the quadrangle, is of prime importance, since it is the source whence the oil and gas are derived. It contains the Bandera shale, Pawnee limestone, Labette shale, Fort Scott limestone, and Cherokee shale, named in order from the top down. Of these the Cherokee

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shale, at the base of the series, is the most important with reference to oil and gas. The others are in general similar to the formations outcropping in the quadrangle.

The Pennsylvanian series rests upon the Boone limestone, which belongs to the Mississippian series and is exposed only in the southeast corner of Kansas and in adjacent parts of Missouri, Arkansas, and Indian Territory.

CORRELATIONS AND CORRECTIONS.

Since formation names have been given to the various rocks in the Iola quadrangle, where the first detailed work undertaken by the Survey in the region was done, and since most of these formations extend southwestward into the Independence quadrangle, these names are, so far as practicable, here retained. New names are introduced only where required in grouping together previously named formations on account of the dying out of intermediate limestones. The southwestward extension of the formations from the Iola quadrangle and the disappearance of some of them are shown diagrammatically in fig. 2 (p. 13).

A columnar section of the formations and their subdivisions, as used in this paper and illustrated in Pl. III, is given below, the Parsons being the lowest outcropping formation:

Columnar section of formations encountered in drilling in the Independence quadrangle.

Exposed rocks	Alluvium.
	Pennsylvanian series:
	Elgin sandstone.
	Painterhood limestone.
	Buxton formation.
	Wilson formation:
	Piqua limestone.
	Vilas shale.
	Allen limestone.
	Concreto shale.
	Iola limestone.
	Chanute shale.
	Drum formation.
	Coffeyville formation:
	Cherryvale shale.
	Dennis limestone.
	Galesburg shale.
	Mound Valley limestone.
	Ladore-Dudley shale.
	Parsons formation.
Underlying rocks	Bandera shale.
	Pawnee limestone.
	Labette shale.
	Fort Scott limestone.
	Cherokee shale.
	Mississippian series:
	Boone formation.

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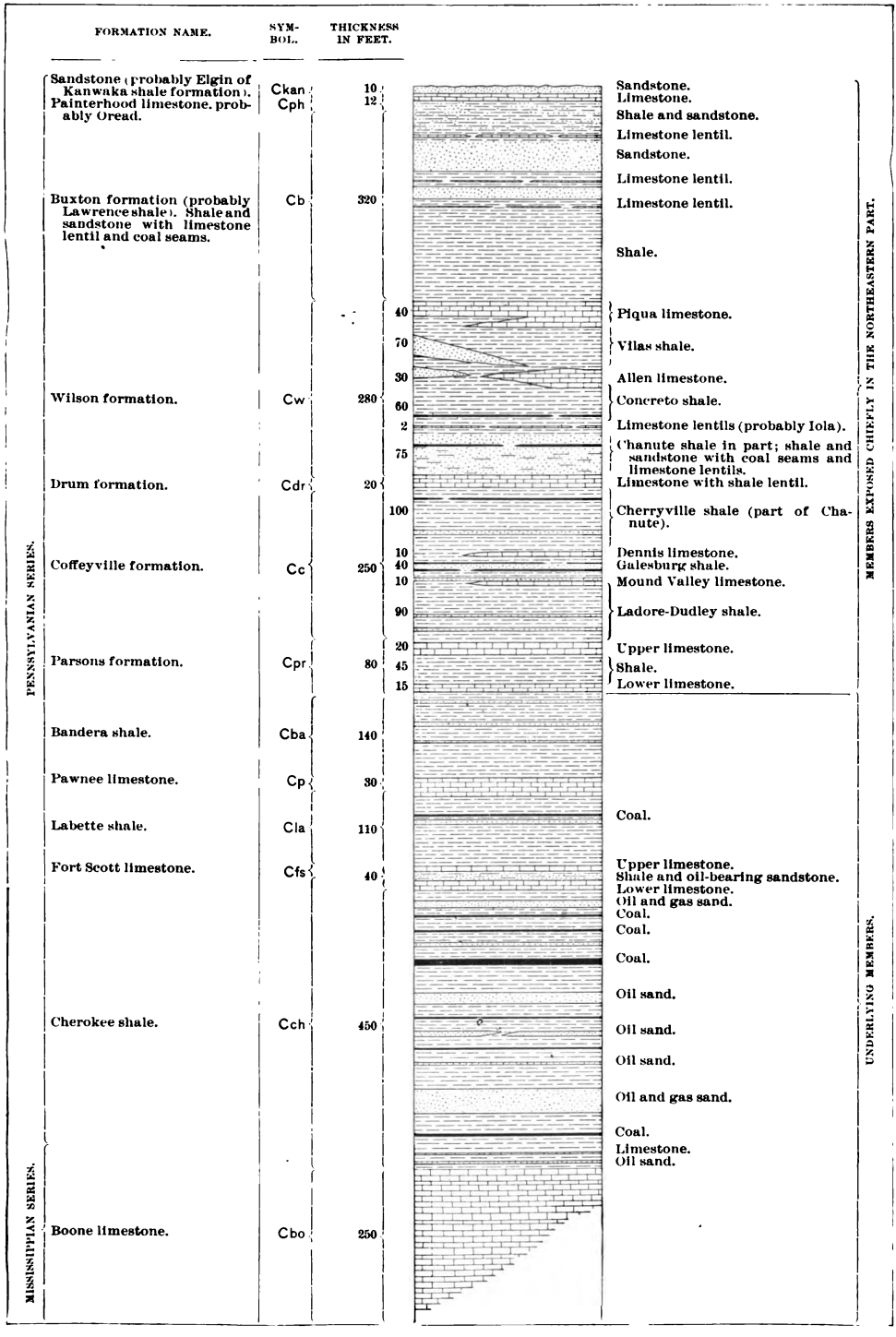

GENERAL COLUMNAR SECTION OF ROCKS EXPOSED AND ENCOUNTERED IN DRILLING.

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ROCKS.

ALLUVIUM.

The alluvium consists of the recent stream-laid deposits of soil, clay, sand, and gravel that form the lowlands in the partly infilled valleys along Verdigris River and its larger tributaries. This is commonly known by drillers as "soil" or "made ground." In some localities it has a thickness of 35 or 40 feet. Along the Verdigris it forms a belt about 2 miles in width, and its surface deposit consists of a layer of black, heavy soil, which forms rich agricultural land.

PENNSYLVANIAN SERIES.

ELGIN SANDSTONE.

The uppermost consolidated formation occurring in the Independence quadrangle is a brown medium-grained sandstone, tentatively correlated with the Elgin sandstone,[a] included by Haworth in the Kanwaka shales. Merely the edges of this sandstone, reduced by erosion to a thickness of only 10 feet, occur in this quadrangle, at the extreme northwest corner, where they constitute its highest ground. The sandstone overlies the Painterhood limestone and thickens materially to the northwest beyond the quadrangle boundary.

PAINTERHOOD LIMESTONE.

Like the sandstone just described, the Painterhood limestone, which probably represents the Oread limestone of Haworth,[b] occurs only in the northwest corner of the quadrangle, where it overlies the Buxton formation and occupies an area of less than a square mile. It forms a scarp of considerable prominence along its line of outcrop. It has a thickness of about 12 feet. It is reddish gray, semicrystalline, fine grained, and fossiliferous. It has supplied much of the building stone used in the construction of the Kansas State University and other buildings.

BUXTON FORMATION.

The Buxton formation probably represents both the Lawrence and the Leroy shales of Haworth.[c] It lies along the western edge of the quadrangle, where its breadth of outcrop narrows from about 8 miles at the north to about 2 miles at the south. In the northern part of the quadrangle it is limited on the east by a well-defined eastward-facing scarp, 100 feet high. It has a thickness of about 320 feet and

[a] Univ. Geol. Surv. Kansas, vol. 3, 1898, p. 64.
[b] Kansas Univ. Quart., vol. 2, 1894, pp. 123–124.
[c] Ibid., p. 122.

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contains a large amount of sandstone, to which is due the rugged hilly topography in the western part of the quadrangle. It contains economic deposits in the form of coal seams, brick shale, building sandstone, and some sandstone which is being exploited for the manufacture of glass. The shale pits of the brick plants at Caney and just north of the quadrangle, at Fredonia, are excavated in its lower part. It contains also some thin beds and lenses of limestone, of which those outcropping on Willow Creek and about Elk are the most important.

WILSON FORMATION.

The name Wilson formation, after Wilson County, in the southeast corner of which the rocks are widely exposed, is here adopted for all of the geologic section included between the base of the Buxton and the top of the Drum. It comprises six subdivisions, which to the northeast, in the Iola quadrangle, have received formation names.[a] These, in descending order, are the Piqua limestone, Vilas shale, Allen limestone, Concreto shale, Iola limestone, and Chanute shale (in part). In the Independence quadrangle some of these are discontinuous and others, particularly the limestones (Pl. I and fig. 2), die out, so that the six are here grouped into the Wilson, which is, in this quadrangle, essentially a shale-sandstone formation. It has a thickness of 280 feet (Pl. III), and outcrops in a belt about 16 miles wide, extending diagonally across the quadrangle in a northeast-southwest direction.

Piqua limestone.—The Piqua is one of the most important and prominent limestones of the quadrangle. It varies in thickness from 50 feet at the north edge to 1 or 2 feet at the south edge, where it extends into Indian Territory. In places it thickens materially, as at Elk, where the log of the well drilled on the bank of Duck Creek gives its thickness as 112 feet. It outcrops in a belt from 1 to 8 miles wide extending across the quadrangle from north to south. It caps the scarps and mounds on the west side of Fall and Verdigris rivers in the northern part of the quadrangle, whence its eroded surface forms a dip plain sloping gently westward from Neodesha and Sycamore to the foot of the Buxton scarp, beyond Lafontaine and Elk. Here it consists of a single massive terrane, which weathers in coarse, rough blocks. It is whitish or light gray in color and is medium to coarse grained, pure, and the most completely crystalline of all the limestones encountered. Probably more than half its mass consists of coarsely crystalline calcite. It is believed that it will prove exceptionally valuable in the manufacture of Portland cement, for which purpose it is to be used in a plant at Table Mound, on Elk River. To the south it loses its purity, becomes oolitic, arenaceous, and finally

[a] Bull. U. S. Geol. Survey No. 238, 1904, Pl. I.

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conglomeratic, and consists of two or more thin beds of limestone with some intercalated shale.

Vilas shale.—This rock is exposed mainly in the scarps and bluffs west of Fall and Verdigris rivers. It is compact, usually light or

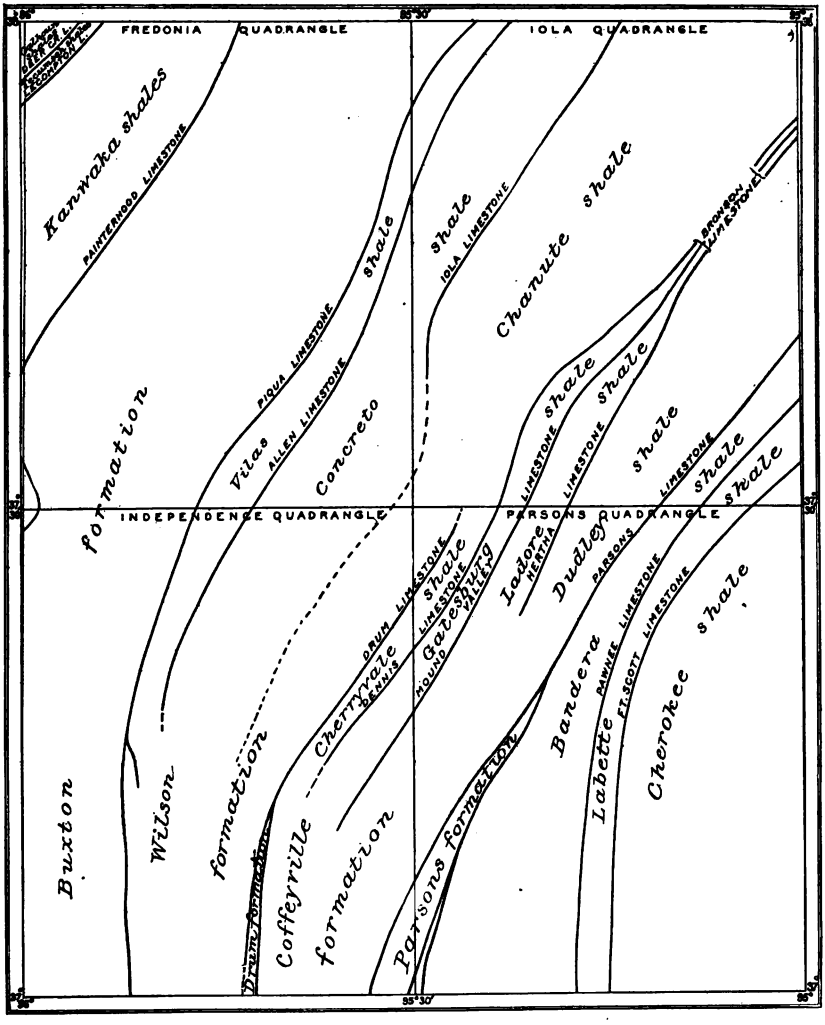

FIG. 2.—Diagram of formations exposed in the Independence and adjacent quadrangles, showing limestones dying out to southwest.

yellowish, and thickens from 20 feet at the north edge of the quadrangle to 80 feet at Table Mound.

Allen limestone.—The Allen limestone is present in that part of the section which forms the Fall and Verdigris rivers scarps and extends from the north edge of the quadrangle southward to Table Mound.

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It varies from 5 to 70 feet or more in thickness and thins to the south, its southernmost recognized outcrop being at Crane. Its average thickness is about 30 feet. It is massive, semicrystalline, compact to coarse grained, fossiliferous, and at many places dark blue in color. A plant is being erected at Little Bear Mound, Neodesha, at which it will be used in the manufacture of Portland cement.

Concreto shale.—The Concreto is essentially a clay shale, having a thickness of about 60 feet. It also contains much heavy-bedded brown and greenish sandstone, which at various localities furnishes handsome building, paving, and curb stone, and which is extensively quarried near Independence and Neodesha. At Neodesha the shale is also to be used, with the overlying Allen limestone, for Portland cement.

Iola limestone.—Thin limestone beds and lentils, rarely exceeding 2 or 3 feet in thickness, are exposed at Independence and on Choteau and Chetopa creeks and other small streams tributary to the Verdigris on the east. These beds, from their lithologic character and their occurrence near the horizon of the Iola limestone, are believed to be the southwestward extension of this formation.

Chanute shale (in part).—The Chanute shale occupies a belt having an average width of about 5 miles, extending from the northeast corner of the quadrangle southwestward into Indian Territory. It is about 75 feet thick, and consists of shale and sandstone in nearly equal proportions. On the north it forms the broad upland that slopes gently westward from Thayer to Neodesha and Verdigris River. In its upper part it contains the Chetopa Creek, Thayer, and other coal beds; toward the south it contains much sandstone, which is used locally for building purposes.

DRUM FORMATION.

The Drum formation in the vicinity of Independence consists of a single bed of limestone. Farther south it comprises three members—a lower, heavy-bedded, massive limestone 12 feet thick; an upper, thin-bedded, hard, blue, often flinty and flaggy member 2 to 10 feet thick; and an intervening shale member 10 to 25 feet thick. In some localities, particularly in the northwestern part of Parker Township and the southwest corner of Liberty Township, where it caps the bluffs that overlook the Verdigris, the thin-bedded, flaggy member is overlain by a coarse-grained, heavy-bedded, stony limestone, about 5 feet in thickness, which weathers very rough and is deeply pitted.

COFFEYVILLE FORMATION.

The name Coffeyville formation, after the town of Coffeyville, is here adopted for the portion of the geologic section included between the base of the Drum and the top of the Parsons. It comprises six

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or more members, which to the northeast, in the Iola quadrangle, have received formation names.[a] These members, in descending order, are the Cherryvale shale, Dennis limestone, Galesburg shale, Mound Valley limestone, Ladore shale, Hertha limestone, and Dudley shale. On the south the Coffeyville consists wholly of alternating beds of shale and sandstone, while toward the northeast occur lentils of the Dennis and Mound Valley limestones, representing the dying out of these terranes. The formation has a thickness of 250 feet and outcrops in a broad northeast-southwest belt.

Cherryvale shale.—This member has a thickness of about 100 feet. It is light colored and in the main is an excellent brick shale, but it contains some sandstone and also seams of coal, one of which on Onion Creek, 4 miles west of Coffeyville, is 18 inches thick. This shale is unusually fragile and easily disintegrated, which accounts for the steep slopes which occur in it.

Dennis limestone.—The Dennis limestone has a thickness of about 10 feet. It is medium grained, hard, bluish gray, semicrystalline, and fossiliferous; but owing to the hardness of the underlying shale it does not form prominent scarps. Its southernmost recognized outcrop is on Drum Creek, about 4 miles north of Liberty and 5 miles east of Independence.

Galesburg shale.—This shale, underlying the Dennis limestone, is about 40 feet thick. It consists in the main of red, arenaceous shale, but contains also some heavy beds of micaceous sandstone and thin seams of coal. Much of it weathers a pronounced rusty brown, denoting the presence of considerable iron. It thins rapidly to the north, and at Porterville, in the Iola quadrangle, is merely a member of the Bronson limestone.

Mound Valley limestone.—This limestone is known to be present in the Independence quadrangle only in that part of the area lying northeast of Liberty. It dies out west of Big Hill Creek, about a mile north of Liberty. It has an average thickness of 10 feet, and is fine grained, semicrystalline, and fossiliferous. Owing to its hardness and the softness of the underlying shale, it forms prominent scarps where incised by the streams.

Ladore-Dudley shale.[b]—This lower member of the Coffeyville formation has a thickness of about 90 feet, and consists essentially of soft, compact, argillaceous or arenaceous, thin-layered shale, with but little interstratified sandstone. It is a good brick shale, and is used in making brick and tile at Coffeyville and brick at Mound Valley. To the northeast, in the Iola quadrangle, it contains nonworkable beds of coal 6 inches in maximum thickness.

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[a] Bull. U. S. Geol. Survey No. 238, 1904, Pl. I.

[b] The term Ladore-Dudley is here used to designate the horizon that is the equivalent of the Ladore shale, the Hertha limestone, and the Dudley shale. The limestone dies out in the northern part of the Parsons quadrangle, as shown in fig. 2.

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PARSONS FORMATION.

Counted from the base upward, the Parsons is the third limestone-bearing formation in the Coal Measures. It is the lowest formation exposed at the surface in the Independence quadrangle and outcrops in a belt about 8 miles wide, trending across the southeast corner and extending laterally from Coffeyville southeastward to beyond Snow Creek. It is exposed in the banks of the Verdigris and its tributaries, and in the surrounding hills. In the Independence quadrangle it has a thickness of about 80 feet, but to the northeast, in the Parsons and Iola quadrangles, it gradually thins to 10 or 15 feet. In the Independence quadrangle it consists of three members—a lower limestone 15 feet thick, an upper one about 20 feet thick, and an intervening shale member about 45 feet thick.

The lower limestone member is compact, bluish gray, and semi-crystalline, contains considerable chert, and consists of two limestone beds, separated by a 2- to 3-foot interval of dark slaty shale. The lower bed is the harder and more crystalline of the two, and is easily identified by the massive and persistent deposits of large corals (*Favosites*) which it contains.

The upper limestone of the Parsons formation is more crystalline and less compactly bedded than the lower. Its basal portion is shaly and nodular. The upper part is heavy bedded and forms prominent scarps where incised by streams; but usually weathers into gentle slopes and furnishes a dark fertile soil.

BANDERA SHALE.

At Bandera, its type locality, the Bandera shale has a thickness of about 100 feet and contains considerable thin-bedded sandstone. Beneath the Independence quadrangle it has a thickness of about 140 feet.

PAWNEE LIMESTONE.

The Pawnee is a massive limestone formation that has a thickness of 30 feet (Pl. III) beneath the Independence quadrangle.

LABETTE SHALE.

The Labette shale averages about 110 feet in thickness beneath the Independence quadrangle, contains but little sandstone, and is without character to distinguish it from other shales of the series.

FORT SCOTT LIMESTONE.

The Fort Scott is the lowest Coal Measures limestone encountered in this area. It has a thickness of about 40 feet and comprises three members—an upper limestone 10 feet thick, a lower limestone 15 feet thick, and an intervening shale 15 feet thick.

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CHEROKEE SHALE.

The Cherokee shale is the principal oil and gas reservoir of the Kansas–Indian Territory field, and hence is economically the most important formation in the Pennsylvania series. It also contains the largest beds of the workable Kansas coals. It is a compact shale, containing at various horizons much sandstone. It varies from 300 to 700 feet in thickness and outcrops in a belt about 38 miles wide, extending from Missouri across the southeast corner of Kansas into Indian Territory.[a] In the Independence area it is deeply buried by the overlying formations, whose aggregate thickness, varying from 320 feet in the southeast to nearly 1,000 feet in the northwest, practically determines the depth at which the Cherokee is found, and consequently also the depth at which the oil and gas contained in it are reached by the drill. To the presence of this overlying impervious blanket of rocks is due the preservation of the oil and gas in economic quantities. East of the quadrangle, where the blanket thins, or in the exposed areas of this shale is absent, the oil and gas have escaped or are escaping by seepage into the outer air and are no longer present in commercial amounts. A study of the outcrops of the Cherokee and of its drill records in the Independence and intervening fields shows that it contains considerable sandstone, mainly in the form of discontinuous beds or lentils, in which the oil and gas occur. In the Independence quadrangle, as shown in Pl. III, the top of the formation is approximately at sea level. It has an average thickness of about 450 feet, and gradually thickens to the southwest from less than 400 feet in the the Cherryvale-Neodesha region to nearly 500 feet at Caney.

MISSISSIPPIAN SERIES.

BOONE FORMATION.

The Boone formation is often referred to as the Boone limestone, and is commonly known to drillers and oil men as the "Mississippi lime." Its upper surface is eroded and presents locally a more or less uneven limestone floor (Pl. II), upon which the Cherokee shale rests. It consists of a number of chert and flint-bearing limestone beds, and contains the noted Galena and Joplin zinc and lead deposits in southeastern Kansas and southwestern Missouri.

In the oil and gas fields the Boone has been penetrated by the drill in a number of localities, usually at considerable depths, and in some cases it has been drilled through. Within the Independence quadrangle (Pl. III) it is encountered at about 450 feet below tide level. In the eastern part of the quadrangle, at Coffeyville and Cherryvale, it is found at a depth of about 1,050 feet, at Neodesha

[a] Bull. U. S. Geol. Survey No. 238, 1904, p. 16.

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at 1,130 feet, and in the southwestern part of the quadrangle, at Caney, at 1,560 feet. From these and other drill records the presence of the Boone formation throughout the Kansas–Indian Territory oil and gas field and its general northwesterly dip have been determined. From the few drillings that have passed through it the average thickness in the Independence quadrangle is computed to be about 250 feet.

The Boone is not an oil- and gas-bearing formation, nor have oil and gas been found below it in commercial quantities in the Independence quadrangle.

GENERAL STRUCTURE.

The geologic strata of southeastern Kansas as a whole have a north-northeast and south-southwest strike and a northwesterly to westerly dip of about 20 or 25 feet per mile. For the Independence quadrangle also this statement is true, with certain modifications. The geologic map (Pl. I) shows the strike and outcrop belts of the various formations trending in a north-northeast and south-southwest direction, and the horizontal section A-B accompanying Pl. II, taken at a right angle to the strike, shows the dip of the rocks to be northwestward at the rate of about 20 feet per mile in the eastern part of the quadrangle, gradually decreasing to about 10 to 15 feet per mile in the western part. The general northwesterly dip is interrupted near the middle of the quadrangle by an uplift that has formed a low, broad east-west arch which may be termed the Cherryvale anticline.

The portion of the quadrangle lying north of this anticline has been more extensively elevated than that lying south, and its geologic structure agrees more closely with that of southeastern Kansas as a whole, as given in the preceding paragraph.

In the southern half of the quadrangle, as shown on Pl. I, the general strike veers from north-northeast and south-southwest to more nearly north-south, and the dip becomes nearly due west, the rate varying from 16 feet per mile in the southeastern part of the area, as shown by the Parsons limestone, to about 10 feet per mile in the western part. Other local variations in structure occur; for example, below Independence, at the mouth of Rock Creek on the Verdigris, the Drum limestone dips to the southwest at the rate of about 70 feet per mile, and 2 miles north of Liberty it dips to the southwest at an angle of 20° or more.

The available well logs indicate that this half of the quadrangle also contains in the lower part of its section a northeast-southwest synclinal trough, whose axis passes through the vicinity of Tyro and Caney, pitching to the southwest at the rate of about 18 feet per mile. This trough has a width of about 15 miles. The Wayside-Bolton region lies apparently at its northwestern edge and the Coffeyville

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region at its southeastern edge. From both edges the strata incline toward the vicinity of Tyro at the rate of about 28 feet per mile. The oil and gas in the southern part of the quadrangle occur in connection with this synclinal trough. Possibly to it are due also similar occurrences farther west, in the eastern part of Chautauqua County.

Owing to the general westerly dip of the rocks the minimum depth at which the Cherokee shale is reached is in the southeastern part of the quadrangle.

It is a noticeable fact that as the several limestones in their southwestward extension gradually thin and die out in this quadrangle there is a more than corresponding increase in the thickness of the shale terranes. This thickening to the southwest is, according to deep-well records, shown also by the Cherokee shale, as has already been noted.

The accompanying sections (Pls. II, III), especially their lower portions, are based largely on records of deep wells that have passed through the Pennsylvanian series and penetrated or passed through the Boone limestone. The limestones are represented by conventional patterns and the shales by intermediate blank spaces. The rocks in the field vary slightly in degree of dip and in attitude from place to place, but this could not be shown on the small scale of the sections. As shown in the columnar sections, the well logs record more limestones than have been found exposed at the surface and more than are represented in the horizontal sections. These additional limestones doubtless owe their origin to varying sedimentation. In some cases they represent subterranean members due to the splitting up of surficially exposed limestones and in others they are probably lenses in the shale terranes. Both of these phenomena, as shown on Pl. I, are seen from surface observations to occur frequently.

RELATIONS OF THE OIL- AND GAS-BEARING SANDSTONES.

The reservoirs in which the oil and gas are found are beds or lenticular bodies of sandstone interbedded with the shales. These sandstones are irregular and local in character, varying greatly in their horizontal and vertical extent. They do not form definite horizons, but die out laterally or grade into shale. Their general occurrence may be illustrated by fig. 3, (p. 20)—an ideal sketch of the relation of sandstones contained in a shale formation. In (*A*) the sandstone is lenticular in shape; it thins out and disappears entirely from the section, and has no equivalent. In (*B*) the sandstone is shown to grade into a shale, which is its equivalent. In (*A*) the sandstone is the result of sedimentation at a time when only sand was being deposited. In (*B*) the sandstone represents a period of sedimentation in which both sands and muds were being laid down, according to the local variation in the character of material supplied

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and the strength of the currents which assorted it. As regards these two classes of sandstones, observations have shown that the lens-like beds are apt to be more persistent and to extend for longer distances, while the sandstones which grade into shales vary from place to place

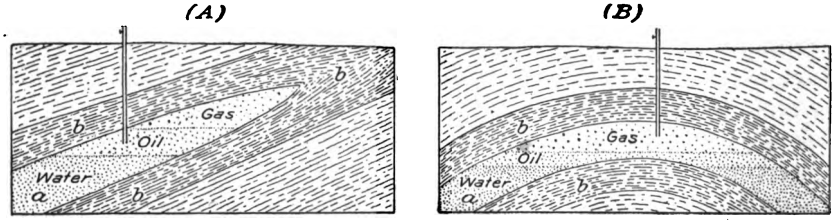

FIG. 3.—Types of natural reservoirs of oil and gas. *A*, inclined bed of sandstone (*a*) sealed in by shales (*b*), but somewhere in communication with water under hydrostatic pressure. *B*, sandstone bed (*a*) interstratified with impervious beds (*b*) and forming an arch, or anticline, and somewhere in connection with water under hydrostatic pressure.

in an exceedingly irregular way. The varying relations of the oil- and gas-bearing sandstones are shown in Pl. V (p. 24), which represents a group of wells east of Chanute.

MINERAL RESOURCES.

OIL.

HISTORY AND GEOGRAPHIC DISTRIBUTION.

General statement.—Of the mineral resources which occur within the Independence quadrangle the most important are oil and gas, found in the lower Coal Measures. The progressive development of these two resources during the last half decade has led to the rapid transformation of southeastern Kansas from a grazing and agricultural district into a region of mining and manufacturing activity and has converted its villages into cities and towns.

The occurrence of oil was known from surface seepage in Territorial days, prior to 1860. The earliest exploitations were begun in what is now Miami County, about 100 miles northeast of Independence. Here oil was first discovered in the spring of 1855 on Wea Creek, east of Paola, where it dripped from fissures in the rocks and formed an oily surface on the streams. Shallow wells, some yielding traces of oil, were soon drilled at this locality and at others near by, where there were further indications of oil. As these wells were limited to 100 or 200 feet in depth by the shortness of the boring apparatus, plans were made to sink deeper wells during the following season. This project was interrupted by the breaking out of the civil war, but during the next three or four years numerous similar wells were drilled to depths of a few hundred feet, yielding traces of oil. In 1865 the St. Louis, or Ernstein, Company is reported to have bored two wells about 10 miles east of Paola, in each of which a small quantity of oil was found. There are two other wells of commercial importance

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in this part of the field—one drilled within the city limits of Wyandotte during the early seventies and the Acers well drilled in Iola in 1873. In the latter part of the eighties a number of wells that produced a few barrels of oil daily were drilled along the State boundary line east of Paola, and about 1890 Mr. Mills, of Pennsylvania, now proprietor of the gas plants at Osawatomie and Paola, prospected around Osawatomie and Neodesha, finding the indications so good that he induced Messrs. Guffey & Gailey to enter the field. Drilling was extended with fair results from Osawatomie and Paola westward to Thayer, Neodesha, Cherryvale, and Coffeyville, the three last named places being in the Independence quadrangle.

The development at Neodesha must be credited to Messrs. Guffey & Gailey, who began operations here early in 1893. They soon found oil in the immediate vicinity of Neodesha, whence they prospected extensively over wide areas throughout almost all of eastern Kansas. They drilled as far northeast as Pleasanton and Mound City and as far west as the western part of Chautauqua County—singularly enough with poor success. They plugged and abandoned almost all the wells they drilled outside the environs of Neodesha. Recent developments show that in many instances they drilled almost on the very borders of productive oil pools, from which others have since reaped rich rewards. They also did considerable "wild-catting" over almost all of Indian Territory, and to a certain extent were the pioneers in what afterwards became profitable developments at Bartlesville, Chelsea, Muscogee, Tulsa, and Red Fork. In 1895 they sold their entire Kansas holdings to the Forest Oil Company. Later the Kansas branch of the Forest Oil Company was reorganized, and obtained a Kansas charter under the name of the Prairie Oil and Gas Company, with headquarters at Neodesha.

During the last half of 1903 and the first half of 1904 many new companies were formed and much development work was done. Success followed, principally in Fall River and Verdigris River valleys. The accompanying map (Pl. I) of Neodesha and vicinity illustrates fairly well the conditions at the middle of 1904. Within the immediate proximity of Neodesha almost every well is productive.

Montgomery County, embracing approximately the southern three-fourths of the Independence quadrangle, did not produce much oil until the last half of 1903. Early in July of that year drilling was begun with success on the now famous Banks land, about a mile northeast of Bolton.

The areas or pools described in the following paragraphs represent the principal regions of operation within the limits of the quadrangle during the summer of 1904.

Bolton pool.—The Bolton pool is about 5 miles southwest of Independence, between Walker Mound and Bolton, on the Atchison,

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Topeka and Santa Fe Railway. Almost its entire area—3½ square miles—is productive of oil. The largest wells of the State are located here. The depth of the first well drilled in this pool was 1,180 feet, the thickness of its oil sand 15 feet, and its production 40 barrels per day. Soon the southeast quarter of section 17 became the site of a number of wells, each with an initial production exceeding 500 barrels per day. The Standard Oil Company completed its pipe line from Neodesha to the Bolton field early in September, 1903. From this time until the middle of 1904 this area was more prominent and popular than any other within the entire State. Derricks were built with surprising rapidity, and wells were drilled as speedily as possible, the greater number of those first drilled being remarkably productive. Drilling extended northward to and around Walker Mound, in section 5. (See Pls. I and IV.) By the middle of 1904 conditions were about as shown on the map, except that probably more dry holes should be represented. At that time the Bolton area had about 200 producing wells.

Wayside pool.—During 1904 prospecting was extended southwestward from Bolton, and at a distance of from 5 to 6 miles, between Wayside and Havana, another very productive oil area, known as the Wayside pool, was found.

Tyro pool.—In the winter of 1903–4 a good oil well was drilled close by the railroad track about 200 yards east of the station at Tyro, on the Missouri Pacific Railway, and during the year 1904 a number of wells were drilled in that vicinity and also to the south and southeast. Probably the best well thus far drilled in this field is immediately south of Tyro, within 100 feet of the southern boundary line of the State. Free flowing it filled a 200-barrel tank each day during the first week of its existence and is still an excellent producer. During the summer of 1904, also, a good pool was developed in section 16, about 4 miles southeast of Tyro.

Caney pool.—In the southwestern part of the quadrangle, a few miles east of Caney, is the Caney pool. The wells are situated principally along the Missouri Pacific Railway, about midway between Caney and Tyro, but there are also some wells south of this area.

Coffeyville area.—Oil has been discovered in considerable quantities both southeast and northeast of Coffeyville and to some extent within the town limits. During the summer of 1903 the Atlas Oil and Gas Company, drilling for oil southeast of Coffeyville, found, at a depth of 350 feet, a shallow oil sand which within a limited area was fairly productive. The Springfield Company, also, in drilling northeast of town in the angle between Verdigris River and the Missouri, Kansas and Texas Railway, just outside the town limits, found a fair-producing shallow oil sand.

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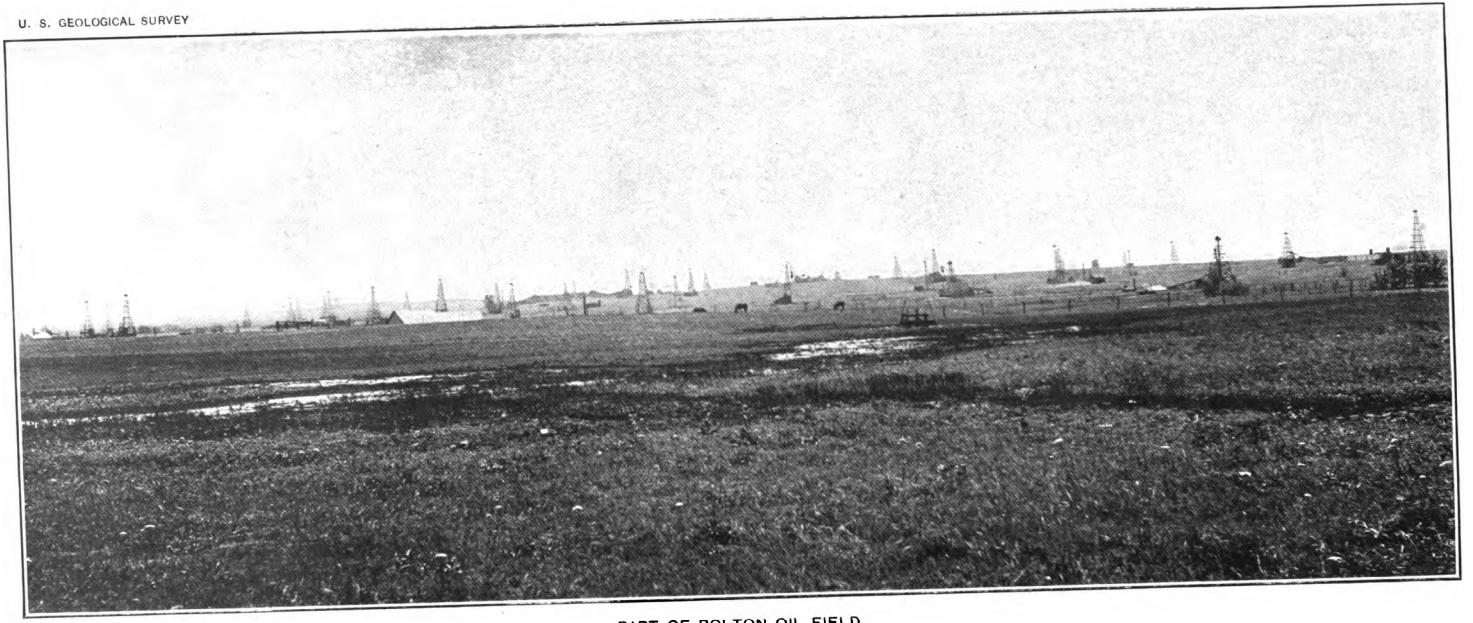

PART OF BOLTON OIL FIELD.

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Drum Creek pool.—About 3 miles southeast of Independence a small but promising area, commonly known as the Drum Creek pool, was developed during 1904. It is situated on both sides of Verdigris River, principally on the east side, along the line between Tps. 33 and 32, in secs. 33, 34, 35, 23, 2, and 4.

Cherryvale area.—This area embraces the country around Cherryvale, in the middle eastern part of the quadrangle. Oil has been obtained in fair quantities on the uplands 1 to 2 miles northwest of town, and during the summer of 1904 it was found, also, from 2 to 3 miles to the south and southeast, mainly in secs. 20 and 23.

Salt Creek pool.—This a small but good oil pool which has been developed on Salt Creek about 4 miles southeast of Neodesha, just within the borders of Montgomery County, east of Verdigris River and about 2 miles west of the St. Louis and San Francisco Railway. It lies in sec. 2, T. 31 S., R. 16 E.

Neodesha area.—Neodesha has long been known as a center of production of oil in the Kansas field. The Standard Oil Company's refinery and tanks are located here. The oil is found principally in the immediate vicinity of the town, and the wells are so numerous that they can not be accurately represented on the map.

Sycamore-Crane area.—This area consists of a belt about 2 miles in width, lying near the center of the quadrangle, northwest of Independence, and extending from Sycamore southwestward via Larimer to Crane and Table Mound at Elk River. It lies between and nearly in line with the Neodesha and Bolton pools, with which future work may connect it. It has produced some oil wells, but none of great size.

Northwestern part of quadrangle.—Drilling around Elk and near Lafontaine has resulted in oil wells of small production at each place; but prospecting in the northwest quarter of the quadrangle has not been very satisfactory, in part because of the increased labor and expense in drilling due to the greater depth of the oil-bearing sands.

OCCURRENCE OF THE OIL.

Though small bodies of oil are frequently found at depths of a few hundred feet below the surface, the larger deposits occur at greater depths in and near the Cherokee formation. At Coffeyville, where the strata overlying the Cherokee are thinner than at any other point in the quadrangle, three oil sands are encountered at depths of 350, 600, and 900 feet, respectively. The best wells, yielding oil of 32° B. gravity, derive their oil from the middle or 600-foot sand. A well in the SE. ¼ sec. 17, in the Bolton pool, encountered two strata of oil sand—one, 15 feet thick and very rich in oil, at a depth of 1,056 feet, and the other, 30 feet thick, at a depth of 1,156 feet. During the first

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flow of oil from these sands the well is reported to have produced 1,000 barrels a day.

In the Independence region the productive zone ranges in depth from 450 to 600 feet; at Cherryvale, from 700 to 800 feet; at Neodesha, from 800 to 900 feet; at Bolton and Caney, from 1,000 to 1,200 feet, and at Wayside, midway between Bolton and Caney, two oil sands occur at depths of 700 to 800 feet and 1,350 to 1,450 feet. The sands encountered between 1,350 and 1,450 feet probably correspond roughly to those of the Tyro pool, where most of the oil is struck at about 1,300 feet. This is also approximately the depth at which the oil is reached in the Bartlesville district, Indian Territory.

For convenience of comparison these depths are indicated in the following table:

Depths of oil-bearing strata in Kansas-Indian Territory field.

	Feet.		Feet.
Bartlesville, Ind. T.	1,300–1,600	Independence, Kans.	450–600
Bolton, Kans.	1,000–1,200	Neodesha, Kans.	800–900
Caney, Kans.	1,000–1,200	Sycamore, Kans.	700–800 1,100–1,200
Cherryvale, Kans.	700–800	Tyro, Kans.	1,300
Coffeyville, Kans.	600	Wayside, Kans.	700–800 1,350–1,450
Drum Creek, Kans.	450		
Fredonia, Kans.	1,100–1,150		

Though these variations in depth are in some instances influenced by surface relief, the intimate association of dry holes with productive wells, as shown by comparison of the well logs of any of the districts, indicates that the country is spotted and that the oil does not occur in a single continuous stratum of sand or a definite horizon underlying the field, but in disconnected lentils, beds, or other sandstone bodies contained at various horizons in the shale formations.

The sandstone bodies are merely the lodgment places or reservoirs and not the sources of the oil and gas. The storage capacity or porosity of a reservoir of given size depends on the texture of the rock, the shape and uniformity in size of the grains, and the quantity of cementing material present. The porosity of an ordinary fine-grained sandstone is from 8 to 10 per cent. The bodies of highest economic value are those that are completely sealed in by impervious shales in which the sandstones are interbedded.

The productive sand is frequently known as "sugar" sand. The variation of horizon at which it occurs is shown in the accompanying illustration (Pl. V), which represents a group of wells east of Chanute in the adjacent Iola quadrangle. In this plate the lower portions of the logs of these wells, showing the sandstones encountered, are presented, drawn to scale. The relative distance between the wells is

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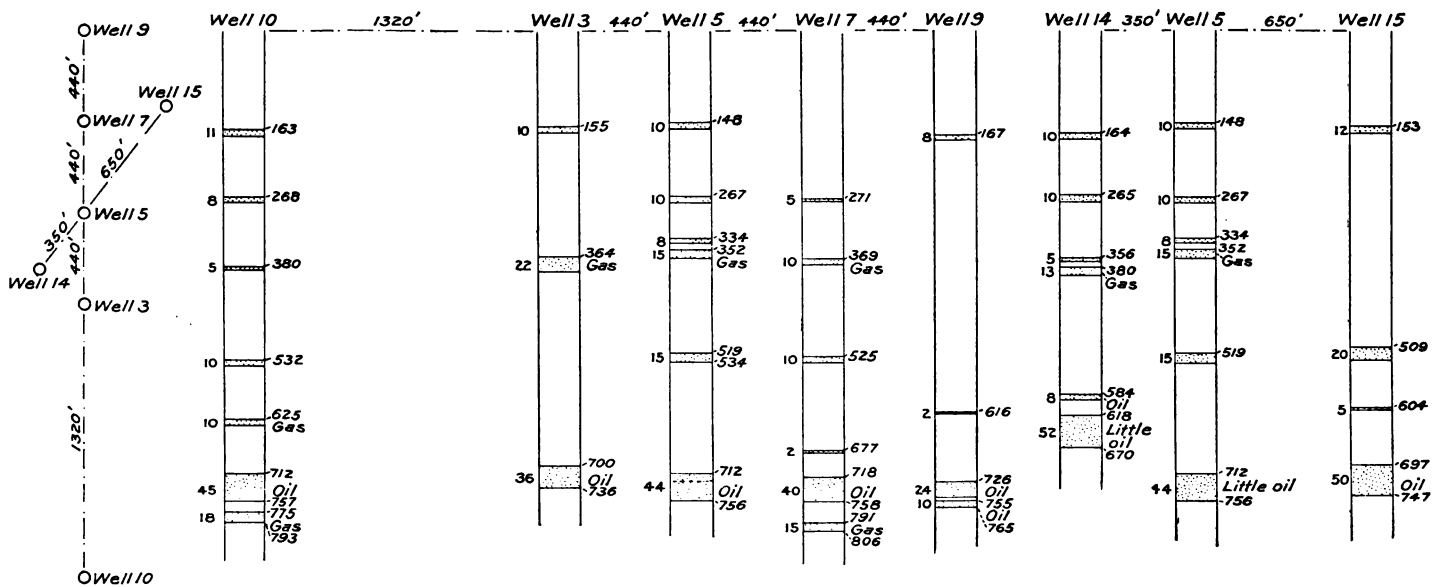

DIAGRAM OF WELLS EAST OF CHANUTE.

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indicated on the diagram and in the arrangement of the well sections. The surface is almost level, the slope being not more than 2 or 3 feet to the mile. A glance shows graphically the irregularity in the horizons at which the sands were encountered. In some cases the records of adjacent wells correspond closely in regard to particular sands, but it will be noted that some of the sands which are well marked in certain wells are wholly absent in others. This leads to the conclusions that the individual sands are irregular in extent and character, that they are exceedingly variable in regard to their contents of oil and gas, and that when both oil and gas are found in the same well the gas-bearing sand may be above or below the oil.

CHARACTER AND VALUE OF THE OIL.

Like all Kansas oils, the oil of the Independence quadrangle has an asphaltum base. It is dark brown or black in color and heavy, but varies greatly in specific gravity from place to place, sometimes within narrow geographic limits. That derived from shale, as in the petroleum fields of California, is generally lighter than that derived from sandstone and conglomerate.

It is found that by the evaporation of its lighter volatiles oil standing in an open tank decreases in gravity at an average of 1° a week for the first few weeks, thus losing in value about 10 cents per barrel per week. A test made with oil fresh from the pump showed a loss of more than 7.3° in three months. The evaporation is much greater in dry or warm than in wet or cold weather. This loss probably accounts for the fact that the oil in many instances tests below the expectations of the producer, who nearly everywhere uses open tanks, usually of wood, without a protecting cover. The Standard Oil Company avoids this great loss, as far as possible, by making its tanks practically air-tight and by closing them immediately after they are filled.

When the Standard Oil Company first began buying oil and established a general market in these fields it divided the Kansas territory into two divisions, named North Neodesha and South Neodesha. As the division line between the two areas thus created is the township line, about 3 miles north of Fredonia and 9 miles north of Neodesha, the whole of the Independence quadrangle lies in the South Neodesha division. This division contains the heavier oil, for which, until recently, the company has constantly paid 20 cents per barrel more than for oil from the North Neodesha division. Early in the summer of 1903 South Neodesha oil sold as high as $1.38 per barrel, the highest price ever reached by Kansas oil.

Late in the year 1904 the Standard Oil Company revised this mode of classifying oils and began buying by gravity tests. It set its highest price on oil with a gravity of 32° B. (0.8641), which it still

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calls South Neodesha oil. Oils heavier than this were discounted 10 cents per barrel for each degree, so that an oil testing 28° B. (0.8860) was priced at 40 cents per barrel below that testing 32°. It has not increased the price for oils above 32°, although much of the oil tests considerably higher. Oil from the Bolton region varies slightly from well to well, but ranges about 34° B. (0.8536); Neodesha oil in general runs about 36° B. (0.8433); and oil from the eastern part of Montgomery County, around Cherryvale and Coffeyville is variable, some of it being heavy enough to fall below 30° B. (0.8750). This readjustment of prices practically amounted to a considerable reduction in the total amount of money paid for Kansas oil.

The prices paid by the Standard Oil Company for Kansas oil, as compared with those for other American oils, are shown in the following table:

Prices per barrel of Kansas oil and of other American oils in 1904.

Pennsylvania	$1.60	Kansas oil, 28½° gravity	$0.52
Tiona	1.75	South Neodesha	.87
Corning	1.37	Corsicana, light	.85
Newcastle	1.47	Corsicana, heavy	.50
North Lima	1.07	Kansas, heavy	.46
South Lima	1.02	Bartlesville, Ind. T.	.87
Indiana	1.02	Somerset	1.01
Kansas oil, 30° gravity	.67	Ragland	.60
Kansas oil, 29° gravity	.57	Petrolea (Ont.)	1.53

When Pennsylvania oil is $1.60 the best grade of Kansas oil is 87 cents, a difference of 73 cents per barrel. This difference has been maintained with but slight exceptions all through the variations in prices of oil during the last three years. Notwithstanding the present low price of oil, due to overproduction and want of purchasing competition, the energies of the producer, who is largely responsible for the glutted market, show no abatement in prosecuting the work of development.

DEVELOPMENT OF THE OIL INDUSTRY.

WELLS AND PIPE LINES.

The greater part of the field is operated under the lease system, by which gas delivered for domestic use on the premises is frequently included. The Osage Indians are reported to receive $50,000 annually for a blanket lease covering their country. There are also intermediate companies, which lease and buy up both large and small exploitation areas and chart and sublet them to other companies or operators for development. The area covered by a lease varies from a few acres in or near a highly productive district to many square miles in a

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new or unprospected part of the field. A quarter section is a fair average. The general productiveness of the field tends to prevent abnormally large leases, as the percentage of producing wells to the number drilled is very high—higher, it is claimed by some, than in any other field in the world.

The peculiarities of location of the wells shown on the map (Pl. I) are explained in part by the fact that each operator must confine his drilling to the area of his own lease and that sometimes a lease covers 160 or more acres and quite as frequently a smaller space. Again, after it is practically determined that the area is productive throughout, the operator usually drills around his border lines in order to protect himself from his neighbor, who may be drilling on adjacent ground. Hence, there sometimes results a row of wells around the border of an operator's lease, as is illustrated in the NW. ¼ sec. 9, T. 33 S., R. 15 E.

Since about 1896 commercial operations in the Kansas–Indian Territory field have been largely in the hands of the Prairie Oil and Gas Company, the Kansas branch of the Standard Oil Company. This company is not an exploiter or developer of territory, nor a producer, but a dealer, since it purchases the oil from the producer and refines and markets it. Its expenditures, however, have been so great that it has become a most important factor in the general development. During the latter half of 1903 and the first half of 1904 many new companies were formed, which have done much development work.

Owing to higher freight rates oil-well supplies are reported to cost about 5 per cent more than in the Pennsylvania fields, but the nature and attitude of the formations render drilling easy. The cost of drilling is only about 90 cents per foot, and the rate, under average conditions is about 100 feet per day. This fact, together with favorable climate, topography, and railroad facilities, has made it possible for development to proceed at a very rapid rate. The railroad facilities are now being further increased by the construction of interurban electric systems by the Union Traction Company, which contemplates extending its service throughout southeastern Kansas.

In a considerable portion of the Kansas field the basis of appraisement for taxes for oil wells is $405 each, and the net assessment is one-third of this amount, or $135. The oil men are asking for a reduction of these figures to a net valuation of $100 on each well and a valuation of other property and equipment in proportion.

The rate of development in the quadrangle is well indicated by the reports of operations issued by the pipe-line department of the Prairie Oil and Gas Company. Its reports for the period extending from July to December, 1903, show a total of 440 wells producing at the end of the year, or a gain of 254 wells in six months.

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Producing wells in and near Independence quadrangle, July–December, 1903.

District.	Wells producing July 1, 1903.	July.		August.		September.		October.		November.		December.		Total wells producing Dec. 31, 1903.
		Completed.	Abandoned.	Completed.	Abandoned.	Completed.	Abandoned.	Completed.	Abandoned.	Completed.	Abandoned.	Completed.	Abandoned.	
Chanute	306	45	0	16	0	25	0	25	1	81	2	56	2	549
Humboldt	133	14	0	35	17	65	21	68	15	44	16	65	16	339
Neodesha	161	18	5	35	12	18	5	29	9	39	2	23	10	280
Peru	32	9	1	30	19	32	11	25	4	30	7	29	3	151
Independence	7	10	7	36	18	8	4	32	11	49	10	25	6	111
Cherryvale	18	4	1	10	1	.....	.....	.....	.....	18	1	2	0	49
Bartlesville, Ind. T.	84	7	1	8	1	13	3	5	0	12	2	6	1	77
Chelsea	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	5	28
Red Fork, Ind. T.	1	2	.....	.....	.....	.....	.....	.....	.....	3	.....	.....	.....	6
	725	109	15	170	59	161	44	184	40	276	40	206	43	1,590

The report of the same company for the month ending January 25, 1904, shows 66 wells drilled, 28 abandoned, and an increase from 440 to 478, or 38 producing wells during the month, with 52 wells in process of drilling and 32 rigs up or partly up. Activity was almost wholly confined to the country about Neodesha and to the Bolton field, which is in the Independence district. Corresponding reports for the months of April, July, and September, 1904, show that from 573 producing wells at the beginning of April the number increased to 655 at the end of the month and to 1,016 at the end of September, a gain of 361 producing wells during the five months.

The July report includes also the Elk, Caney, and Coffeyville areas and the September report includes, in addition to these, the Wayside pool. The largest wells yet discovered are in the Bolton field. One had an initial production of 700 barrels per day, while others flowed about 500 barrels per day for a number of weeks. A great many have been obtained, however, which produced from 100 to 200 barrels per day at first, and have maintained a good pumping production to the present time.

With regard to the entire Kansas–Oklahoma–Indian Territory field, statistics furnished by the division of mining and mineral resources show that there were 391 producing wells in Kansas at the beginning of 1903, which number increased to 1,145 by the end of the year and to 2,782 by the end of 1904. In Oklahoma and Indian Territory there were 361 completed wells at the close of 1904, of which 243 were oil wells, 21 gas wells, and 97 dry holes, and 70 wells were in process of drilling; January 1, 1903, only 30 wells had been completed, of which 17 were oil wells, 2 were gas wells, and 11 were dry holes. In the summer of 1904 the Indian Territory output was in round numbers 286,000 barrels, which was handled in tank cars, 16 cars daily being shipped from Bartlesville and occasionally one or two from Red Fork, Chelsea, and Muscogee. July 1, 1904, not a well

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had yet been drilled at Cleveland, none at Alluwe, and only two on the Osage lots of the Ochelata-Ramona pool. By July, 1905, it was reported that 1,700 wells had been drilled in Indian Territory and Oklahoma and that the Osage Reservation had a daily production of 16,000 barrels; Cleveland, 12,000 to 15,000 barrels; Alluwe, 4,000 barrels; Tulsa-Red Fork, 15,000 barrels, and the remainder of the Cherokee Nation, 5,000 barrels. In order to keep pace with this rapid development and to take care of the oil produced, a 6-inch and an 8-inch pipe line were laid during the same period from Ramona to Kansas City, also 4-inch lines to Cleveland and Red Fork, to Chelsea, to Chautauqua, and to Paola and Rantoul, and in addition a refinery was built at Sugar Creek, near Kansas City. More than a hundred 35,000-barrel tanks were completed at Humboldt, Caney, Bartlesville, Ramona, Cleveland, Tulsa, Muscogee, and Chelsea, and 7,000,000 barrels of crude oil were placed in storage.

To handle this large amount of oil and the probable increase in the future the Standard Oil Company in the fall of 1904 began to lay a pipe line from the Kansas fields to its large refinery near Chicago, at Whiting, Ind. Here this line meets the Standard's eastern system of pipe lines, at a distance of nearly 600 miles from Kansas City, a direct connection being thus established between the Kansas-Indian Territory field and the Atlantic seaboard. This great line is over 1,800 miles in length, 20,000 barrels are required to fill the pipes, and it takes ten days for the first part of the supply introduced in the West to reach the coast. Although its completion was delayed by change in the right of way, oil was turned into the line at Kansas City July 20, 1905. The line has a complete tankage system, with a capacity of 10,000 barrels, and when fully equipped with the installation of more pumping stations will have a capacity of about 18,000 barrels of oil a day. Its importance to the interior producer can hardly be overestimated, as it means an eastern outlet for Kansas-Indian Territory oil.

At present the Standard Oil Company owns nearly 12,000 miles of pipe line in the Kansas–Indian Territory oil belt, the value of which together with that of its leased oil-producing properties, tankage, and refineries, the cost of the Whiting line and of other projects completed and in course of completion, makes the total investment of the company in this field nearly $15,000,000. That the development of this field as a whole is very recent and very great may be understood when it is realized that the total output was only 368,849 barrels at the end of 1902 and that it had risen to 5,617,527 barrels at the end of 1904.[a] As reported by the Prairie Oil and Gas Company there were 1,609 wells drilled in the Kansas–Indian Territory field during the first five months of 1904, of which 72 per cent were

[a] Mineral Resources U. S. for 1904, U. S. Geol. Survey, 1905, pp. 704-707.

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paying producers in oil, 83 per cent were paying producers in oil or gas, and only 17 per cent were "dusters." For the two months of June and July some decrease in development is reported, but an increase in production.

The drilling is usually done with a standard or carpenter's portable rig of the American cable-tool or oil-well system. The derricks vary in height from 40 to 75 feet.

The following logs of wells show the character of the material encountered in drilling and the depth at which oil and gas are reached in different localities in the quadrangle:

Log of Neodesha deep well, Wilson County, Kans.[a]

	Thickness.	Depth.
	Feet.	*Feet.*
Surface, soil and clay	31	31
Sandstone, fine grained, slightly calcareous	34	65
Shale, gray, calcareous and arenaceous	5	70
Shale, gray, calcareous	43	113
Limestone, light colored	19	132
Shale, bluish	15	147
Limestone, light colored	51	198
Limestone, with black shale	5	203
Sandstone, fine grained	67	270
Limestone, light colored	21	291
Shale, bluish	37	328
Limestone, with shale	16	344
Shale, black	29	373
Limestone, arenaceous	79	452
Shale	105	557
Limestone, with bluish shale	47	604
Shale, black, calcareous	3	607
Limestone, shaly	15	622
Shale, slightly calcareous	33	655
Limestone, with some shale	25	680
Shale, dark, calcareous	153	833
Shale, bluish, slightly calcareous	3	836
Sandstone	4	840
Shale, bluish	4	844
Shale, dark	11	855
Shale, calcareous	38	893
Shale, black	10	903
Shale, with some sandstone	27	930
Shale, black	38	968
Sandstone, with some shale	18	986
Sandstone, light colored	8	994
Sandstone, white, slightly ferruginous	27	1,021
Sandstone, very ferruginous	35	1,056
Shale, black	20	1,076
Shale; bluish	14	1,090
Chert, with shaly material, probably cavings	11	1,101
Limestone, arenaceous	12	1,113
Limestone, arenaceous	6	1,119
Shale, arenaceous	13	1,132
Limestone, cherty	12	1,144
Limestone, arenaceous	4	1,148
Limestone, cherty	73	1,221
Limestone, arenaceous	11	1,234
Limestone, cherty, ferruginous	13	1,253
Limestone, cherty	85	1,338
Limestone, with little shale	4	1,342
Limestone, shaly	8	1,350
Limestone, arenaceous	4	1,354
Limestone, cherty	2	1,356
Limestone, arenaceous, slightly ferruginous	2	1,358
Shale, calcareous	6	1,364
Sandstone, cherty	3	1,367
Sandstone, cherty, calcareous, ferruginous	93	1,460
Limestone, cherty	4	1,464
Sandstone, fine grained	10	1,474
Sandstone, calcareous	8	1,482
Limestone, magnesian, arenaceous	8	1,490

[a] Drilled by the Forest Oil Company; begun in 1895 and completed in 1896; record determined by E. Haworth and G. F. Kay from a study of drill cuttings supplied by E. T. Patterson, who superintended the drilling.

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Log of Neodesha deep well, Wilson County, Kans.—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Sandstone, with calcium and magnesium carbonates	37	1,527
Sandstone, with considerable magnesium carbonate	7	1,534
Sandstone, cherty, with magnesium carbonate	10	1,544
Sandstone, with considerable magnesium carbonate, part cherty and part somewhat ferruginous	45	1,589
Limestone, magnesian, cherty	3	1,592
Sandstone, with magnesium carbonate	4	1,596
Limestone, cherty	2	1,598
Sandstone, with magnesium carbonate	5	1,603
Limestone, magnesian, cherty	35	1,638
Limestone, magnesian, arenaceous	43	1,681
Limestone, magnesian, cherty	3	1,684
Limestone, magnesian, arenaceous	9	1,693
Sandstone, with magnesium carbonate	7	1,700
Limestone, magnesian, arenaceous	8	1,708
Sandstone, with magnesium carbonate	67	1,775
Limestone, magnesian	10	1,785
Limestone, magnesian, arenaceous	5	1,790
Sandstone, cherty, with magnesium carbonate	5	1,795
Sandstone, fine grained, with magnesium carbonate	39	1,834
Sandstone, white	17	1,851
Sandstone, with magnesium carbonate	5	1,856
Limestone, magnesian, arenaceous	38	1,894
Limestone, magnesian, cherty	19	1,913
Limestone, magnesian, arenaceous	23	1,936
Limestone, magnesian, cherty	21	1,957
Limestone, magnesian, arenaceous	22	1,979
Sandstone, cherty, with magnesium carbonate	4	1,983
Sandstone, with magnesium carbonate	4	1,987
Limestone, magnesian, arenaceous	35	2,022
Sandstone, white, part coarse and part fine	90	2,112
Sandstone, coarse, with some feldspar	5	2,117
Sandstone, coarse, some of quartz, angular; an appreciable amount of feldspar	5	2,122
Sandstone, fine grained, much of the quartz angular; some feldspar	3	2,125
Sandstone, coarse, the grains distinctly waterworn; considerable gray colored feldspar	5	2,130
Sandstone, the quartz in many cases angular; some feldspar and a few scales of mica	6	2,136
Sandstone, white, fine grained, the grains mostly angular	5	2,141
Sandstone, much of quartz, angular; some pink feldspar	2	2,143
Sandstone, fine grained	2	2,145
Sandstone, many grains well rounded; considerable gray feldspar	7	2,152
Sandstone, fine grained, angular	4	2,156
Sandstone, quartz rather angular; pink fragments of feldspar	5	2,161
Sandstone, with pink feldspar	2	2,163
Sandstone, fine grained	3	2,166
Sandstone, with pink feldspar	2	2,168
Sandstone, much of the quartz angular; some feldspar	3	2,171
Sandstone, quartz mostly angular; pink feldspar fragments	47	2,218
Sandstone, with some feldspar	10	2,228
Sandstone, many of the fragments of quartz angular, but some well rounded	2	2,230
Sandstone, fine grained, most of the quartz angular; some feldspar	22	2,252

Log of Cherryvale gas well No. 1, Montgomery County, Kans.

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	4	4
Yellow clay and limestone bowlders	15	19
Coal, shaly	½	19½
Soapstone (shale)	2½	22
Limestone, hard	33	55
Soapstone (shale)	15	70
Flint, mixed with gray limestone	13	83
Soapstone (shale)	15	98
Blue shale, with sand shells	35	133
Limestone, gray	11	144
Shale, dark, brittle	15	159
Black muck (first salt water)	1	160
Hard black flint and limestone	2	162
Shale, dark, soft	20	182
Black stone, hard	3	185
Shale, dark	5	190
Soapstone (shale)	10	200
Shale, gritty	17	217

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Log of Cherryvale gas well No. 1, Montgomery County, Kans.—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Shale, dark, soft	4	221
Magnesian limestone	19	240
Shale, dark, brittle	3	243
Limestone, drab	3	246
Soapstone (shale)	5	251
Shale, dark	7	258
Shale, gritty, light	5	263
Limestone	9	272
Shale, dark	6	278
Limestone, dark gray	10	288
Shale, dark	6	294
Sandstone	3	297
Shale, gritty, light	94	391
Soapstone (shale)	25	416
Limestone	20	436
Shale, dark	14	450
Soapstone (shale)	5	455
Sandstone (salt water)	49	504
Shale, dark	2	506
Limestone, gray	29	535
Shale, dark	6	541
Limestone, gray	5	546
Shale	1	547
Limestone	21	568
Shale	8	576
Black sandstone	7	583
Shale	16	599
Sandstone, gas bearing	10	609

Log of Independence well, Montgomery County, Kans.[a]

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	3	3
Yellow clay	4	7
Dark soapstone	13	20
Soapstone with grit	18	38
Soft, black slate	18	56
Soapstone	15	61
Firm sandstone	5	66
Shale and grit	6	72
Fine sand	5	77
White flint	2	79
Soapstone, shale flint	10	89
Shale, sand, and shells	9	98
Sand rock	20	118
Firm sand rock	8	126
Shale	12	138
Hard sandstone	8	146
Shale	2	148
Sand rock	20	168
Soft shale	64	232
Dark rock	3	235
Limestone	1	236
Sandstone	8	244
Fine sandstone	8	252
Coal	¾	252¾
Sand, shale, slate	9¼	262
Sandstone	20	282
Shale	24	306
Black limestone	2	308
Shales	7	315
Limestone	3	318
Shale	10	328
Soft shale	13	341
Soft shale, hard streaks	20	361
Shale	10	371
Conglomerate shale	8	379
Shale	2	381
Black slate	7	388
Slate, shells	8	396
Shell rock	2	398
Light shale	6	414
Magnesian limestone	10	424
Fine sand	19	443

[a] Drilled in 1891 in prospecting for coal.

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Log of Independence well, Montgomery County, Kans.—Continued.

	Thickness.	Depth.
	Feet.	*Feet.*
Sand shale	10	453
Sand, shale, 6-inch gas sand	10	463
Conglomerate rock	10	473
6-inch gas rock, shale	9	482
Black slate	5	487
Sand	10	497
Conglomerate limestone	10	507
Soft shale	11	518
Sand	55	573
Soapstone	2	575
No core	14	589
Soapstone	2	591
Sand shale	9	600
Shale	10	610
Pebble rock, with gas	9	619
Hard shale, black	10	629
Trenton rock	8	637
Black slate	6	643
Conglomerate rock	5	648
Soft sand	9	657
Shale	5	662
Sand rock	10	672
Sand	28	700
Fine clay	6	706
Soapstone	10	716
Shale	10	726
Limestone and flint	11	737
Conglomerate	10	747
Limestone	4	751
Black slate	12	763
Limestone	7	770
Dark slate	8	778
Rock (not known)	4	782
Dark conglomerate	11	793
Dark conglomerate rock	15	808

More recently, drilling at Caney by the Caney Deep Well Company has been extended much deeper for the purpose, it is claimed, of ascertaining if oil can be found in the Devonian or Trenton. Of this deeper drilling the following partial log has been kindly furnished by Mr. S. J. Hatch, civil engineer, of Kansas City:

Partial log of deep well at Caney, Montgomery County, Kans.

	Thickness.	Depth.
	Feet.	*Feet.*
Cherokee shale		1,560
Boone limestone (variable)	262	1,822
Black bituminous shale, with traces of gas and odor of petroleum	35	1,857
Limestone, variable, mostly fine grained	207	2,064
Sandstone, fine grained	11	2,075
Limestone, crystalline, gray	10	2,085
Limestone, crystalline, hard, bluish gray (gas)	15	2,100
Limestone, crystalline, hard, bluish gray (some brownish)	10	2,110
Limestone, crystalline, grayish, fine grained	13	2,123
Limestone, crystalline, bluish gray	17	2,140
Limestone, crystalline, brown, gritty (gas)	141	2,281
Limestone, crystalline, brown, gritty (lighter colored)	62	2,343
Limestone, crystalline, variable	107	2,450
Sandstone, fine grained, white	22	2,472
Limestone, soft, brownish gray (trace of asphalt?)	28	2,500
Limestone, cherty, porous Limestone, granular, light buff Limestone, coarse in part	37	2,537
Limestone, bluish gray, crystalline (oil)	63	2,600
Limestone? and shale?	50	2,650
Limestone, soft, clayey, bluish	100	2,750
Limestone, magnesian, gray, sandy	4	2,754
Sandstone, fine grained, gray to brownish, locally hard	46	2,800

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The bottom of the well, at the depth of 2,800 feet, is inferred to be in the Cambrian, which will probably be passed through in about 500 feet more drilling, the underlying pre-Cambrian granite and other crystalline rocks being encountered at about 3,300 feet. Notwithstanding the fact that traces of oil, gas, and asphalt occur in the lower part of the well, it is not likely that any of these will be found in commercial amounts below the Boone formation. Most of the rocks passed through in this well, particularly those of the Boone formation, were remarkably dry. At present, however, the well is nearly filled with water.

Many of the wells for the first week or ten days of their existence are free flowing, but generally, in the field as a whole, the oil is raised to the surface by pumping. The system usually employed is the shackle-rod system, by which a single plant pumps a large number of wells.

REFINERIES.

Up to the close of 1904 the principal refineries for the Kansas-Indian Territory field were those of the Standard Oil Company, one at Neodesha and one at Kansas City, the latter having been recently installed at a cost of $4,000,000. There is also a small independent refinery, that of the Webster Refining Company, at Humboldt. Plants similar to that at Humboldt are now being installed or are soon to be installed at Cherryvale, Longton, Chanute, Elk, Erie, Niotaze, Paola, Osawatomie, Tulsa, and several other points. The Niotaze refinery plans to extend its pipe line to the Wayside pool, and the pipe line of the Uncle Sam refinery at Cherryvale, in its extension to Kansas City, will pass through Wilson County and part of Woodson County, where there is considerable oil produced which so far has had no market. In addition to those mentioned it is reported that the Producers' Refinery and Fuel Oil Company is erecting a 5,000-barrel refinery and a 25,000-barrel storage tank near Mount Washington, at the eastern limits of Kansas City, 2 miles nearer the city than the Standard's large refinery on Sugar Creek. Its line will extend southward to Wayside. The novel plan of installing a State refinery and causing all pipe lines to be made common carriers under State supervision was enacted into statute by the Kansas legislature; but early in July, 1905, the Kansas supreme court declared the law for the installation of the refinery to be unconstitutional, as the constitution prohibits the State from engaging in industrial enterprises.

TANKAGE.

When the production of oil began greatly to exceed the increased capacity of its Neodesha refinery, in 1902–3, the Prairie Oil and Gas Company purchased 120 acres of ground 2 miles north of Neodesha, on the Missouri Pacific Railway, and began to build huge steel tanks for storing the oil. This plant is known as the company's tank farm. It comprises 124 tanks of 35,000 barrels each, and now has in storage

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more than 4,000,000 barrels of oil. The tanks are circular structures built above ground, about 400 feet apart. Each is surrounded by an emergency moat 75 feet wide, with an earth fire bank raised at the outer edge. Similar tank farms were soon installed at Chanute, Humboldt, Kansas City, and Caney, in Kansas, and at Cleveland, Ramona, and other points in Indian Territory. At present (July, 1905), the company is adding to its tankage at the rate of 14 tanks per month, an increase in storage capacity of about half a million barrels per month.

In localities where the installation of steel or wood tankage can not keep pace with the production, large quantities of oil are stored in earth tanks. At Cleveland 400,000 barrels are thus stored at the time of writing.

FUTURE DEVELOPMENT.

Among the projects that have been discussed in behalf of the future development of the field and the improvement of the market is the construction of an independent pipe line to Port Arthur, on the Gulf of Mexico, about 500 miles distant, where the oil will be able to compete with the open markets of the world. Early in May it was reported that the Producers' Pipe Line Refinery Company, with $20,000,000 capital stock, and headquarters at Oklahoma City, had been chartered for this purpose; but at present it appears that the enterprise is to be fathered by the Mellon-Gates-Cudahy Company, in cooperation with the Shell Company, now owning plants or extensive oil interests at Beaumont or Port Arthur. It is expected that this pipe line, when built, will furnish an outlet for at least 10,000 barrels per day and will afford a southern seaport market for Indian Territory oil about 200 miles nearer than Whiting, Ind. The estimated cost of the line, including the construction of a proposed branch to St. Louis, Mo., or West Memphis, Ark., and the installation of a refinery there, is said to be about $6,500,000.

Reports are also current that the Pure Oil Company, an eastern corporation, contemplates entering the Kansas–Indian Territory field.

PRODUCTION.

The production of crude petroleum in the Kansas–Oklahoma–Indian Territory field for the years 1900–1904 is shown in the following table:

Production, in barrels, of crude petroleum in Kansas-Oklahoma-Indian Territory field, 1900–1904.[a]

Year.	Kansas.	Oklahoma and Indian Territory.	Total.
1900	74,714	6,472	81,186
1901	179,151	10,000	189,151
1902	331,749	37,100	368,849
1903	932,214	138,911	1,071,125
1904	4,250,779	1,366,748	5,617,527

[a] Mineral Resources U. S., for 1904, U. S. Geol. Survey, 1905, pp. 704–707. Oklahoma included subsequent to 1901.

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The following table shows the oil production for the whole field in 1903 and 1904, by months:

Production, in barrels, of petroleum in Kansas-Oklahoma-Indian Territory field in 1903 and 1904, by months.[a]

Month.	1903.	1904.	Month.	1903.	1904.
January	44,528	283,509	August	93,777	549,475
February	42,128	314,766	September	114,722	532,811
March	29,524	339,474	October	128,009	601,937
April	27,168	349,992	November	175,751	641,276
May	63,775	384,715	December	238,528	752,436
June	52,782	356,939			
July	60,433	510,197		1,071,125	5,617,527

[a] Mineral Resources U. S. for 1904, U. S. Geol. Survey, 1905, pp. 704–708.

This table shows a production in December, 1903, at the rate of about 2,860,000 barrels a year. In December, 1904, the rate had risen to a little over 9,000,000 barrels a year.

On the production during the first half of the year 1905 the following incomplete data are available: In June the pipe-line runs for the entire field were 715,396 barrels, an average of nearly 24,000 barrels per day, and July 1 the Prairie Oil and Gas Company had stored in the field 7,573,535 barrels. The following are this company's pipe-line runs from January 1 to June 30, inclusive:

Pipe-line runs, in barrels, of Prairie Oil and Gas Company, January 1 to June 30, 1905.

Month.	Total.	Daily average.	Month.	Total.	Daily average.
January	793,648	25,601	April	549,338	18,311
February	564,482	20,160	May	784,228.69	25,297.7
March	695,908	22,448	June	715,396	23,846

As the tankage has been so limited as to prevent the steady pumping of more than half the leases, it is estimated by the gagers of the company that the total daily production for the Kansas–Indian Territory field aggregates about 65,000 barrels. The production for July shows an increase of nearly 1,000 barrels a day.

The following table gives the total quantity of crude petroleum produced in the United States in 1904, and shows the quantity produced by the Kansas–Indian Territory field relative to that of other fields:

Total quantity and value of crude petroleum produced in the United States in 1904.[a]

State and district.	Quantity.	Value.	Value per barrel.
	Barrels.		
California	29,649,434	$8,265,434	$0.279
Colorado	501,763	578,035	1.152
Indiana	11,339,124	12,235,674	1.079
Indian Territory	1,366,748	5,447,622	.97
Oklahoma Territory			
Kansas	4,250,779		
Kentucky	998,284	984,938	.9866
Tennessee			

[a] Mineral Resources U. S. for 1904, U. S. Geol. Survey, 1905, pp. 679–680.

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Total quantity and value of crude petroleum produced in the United States in 1904—Con.

State and district.	Quantity.	Value.	Value per barrel.
	Barrels.		
Louisiana	[a] 2,941,419	$1,068,605	$0.3633
Michigan, Missouri	2,572	4,769	1.854
New York	938,234	1,526,976	1.6275
Ohio:			
Eastern and southern	5,526,146	8,993,803	1.6275
Lima	13,350,060	14,735,129	1.10375
Mecca-Belden	425	1,583	3.725
	18,876,631	23,730,515	1.257
Pennsylvania:			
Franklin	48,499	193,996	4.00
Pennsylvania	11,251,183	18,311,300	1.6275
Smiths Ferry	1,110	1,807	1.6279
	11,300,792	18,507,103	1.6377
Texas	22,241,413	8,156,220	.367
West Virginia:			
West Virginia	12,636,253	20,557,556	1.6269
Petroleum, Volcano	8,483	26,225	3.11
	12,644,686	20,583,781	1.628
Wyoming	11,542	80,794	7.00
Total	117,063,421	101,170,466	.864

[a] In addition to this quantity, 3,670,000 barrels were produced and unsold at close of 1904.

The above table shows also the striking fact that during 1904 over 52 per cent of the total production of the United States came from the country west of Mississippi River, a region which in 1900 was not considered as an important factor in the world's supply of crude oil, for in that year the Appalachian and Lima-Indiana fields produced 91.25 per cent of the total output, California produced 6.79 per cent, Texas produced 1.31 per cent, and all other fields only 0.65 per cent.[a]

UTILIZATION.

The greater part of the crude oil is purchased by the Standard Oil Company, by which it is refined and marketed; some is used by the Webster refinery at Humboldt; some is exported by Mr. I. N. Knapp, of Chanute, and a relatively small quantity is consumed locally for drilling, fuel, lubrication, manufacturing, and sundry other purposes. The oils distilled at Neodesha vary from 25° to 30° gravity and produce approximately 40 per cent of light oils which go into the market of Kansas and the adjacent States, while the heavier product is sold or utilized for fuel.

The most promising field of usefulness for the low-grade crude oil is as fuel to generate steam, for which purpose it is rapidly being

[a] Mineral Resources U. S. for 1904, U. S. Geol. Survey, 1905, p. 677.

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adopted by the larger manufacturing, packing, and milling plants at Kansas City, Wichita, Hutchinson, Salina, Emporia, and other points, and to some extent by the railroads. The Standard Oil Company has recently tested the Kansas oil for fuel purposes and finds it fully as good as California oil. More recently samples of Wayside crude oil, produced by Messrs. Patty & Reese, were practically tested by the Dold Packing Company's plant at Wichita, with very favorable results in competition with coal at $2.50 per ton. It is roughly estimated that 3 barrels of oil contain as many heat units as a ton of good soft coal and that 5 barrels of the lowest grade of oil are equivalent to a ton of Pittsburg or the best grade of bituminous coal. At present prices, under the new maximum freight rate law, oil can be delivered at almost any town in Kansas at a total cost of about 37½ cents per barrel, which renders oil fuel, even when shipped by railroad, about 40 per cent cheaper than soft coal at $2 per ton. An independent company which has been granted a pipe-line right of way from Cherryvale to Topeka is undertaking to supply Topeka and intermediate points with fuel oil at the rate of 20 cents per barrel.

Another purpose for which crude oil is being satisfactorily utilized is in the improvement of public highways. Its systematic use in some localities has already had excellent results. Its utility for this purpose is very materially enhanced by a substantial asphalt base, which acts as a binder on the sand and detrital dust particles of the road. It follows that oil of the most inferior grade is the best for this use. It is said that it is of the utmost importance to apply only the right quantity of oil, which varies with the character of the road from 1,000 to 2,000 gallons per mile, and that two applications a year for streets and one for pikes will completely eliminate the dust.

Among the localities beyond the borders of Kansas where oil is used for road purposes a few may be noted. The report of the department of highways of California shows that the length of oiled roads and streets in that State is about 2,800 miles, distributed in 37 different counties. The California roads are ordinarily dusty and sandy, but are put in good condition at a cost of $200 to $300 per mile; subsequent applications require less oil and are therefore cheaper. Gratifying results are also reported from experiments with oil on the streets and roads of Fayette County, Ky. In Lexington, the county seat, sprinkling the streets with water has been abandoned. Similar experiments conducted in New York are also reported to be perfectly successful. The first Kansas experiments in the use of oil for highway purposes are of recent date. It is being tried at Paola; near Garden, Finney County, in the dusty, sandy region of the Arkansas River Valley, and elsewhere, with the reported excellent result that it lays the dust and tends to compact and bind the surface of the roads.

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FUTURE PROSPECTS.

The Kansas-Indian Territory field possesses to a marked degree the most important conditions governing the occurrence of oil in economic quantities, namely, an abundant supply of porous sandstone reservoirs in which it may be stored and a sufficient covering of impervious shale and limestone to prevent its escape.

Since the entire area of the Independence quadrangle lies within the field and is underlain by the oil-bearing formations, and since much of it has not yet been prospected, any part of the unprospected portion may become productive when drilled. From the prospecting and development that has been accomplished, however, it does not seem likely that the production of the quadrangle will ever much exceed its present rate. In fact, the life history of the wells and pools seems to show that the quadrangle will do well if it can maintain the present rate for any considerable number of years, for oil, however abundant, stored in any locality by nature, is limited in quantity, and when a reservoir is once exhausted it will not be replenished.

To the west of Chautauqua County, in Cowley County, oil-bearing sands have recently been found at Winfield at the depth of 1,600 feet, and at Dexter at 1,400 feet, the sands at Winfield being 35 feet thick but not yielding oil in paying quantities. This fact, considered in connection with the depth, makes it seem improbable that the productiveness of the Kansas-Indian Territory field will ever be found to extend thus far westward.

GAS.

HISTORY AND DISTRIBUTION.

Thus far gas has been discovered in 10 counties of the 105 in the State of Kansas. Its history and distribution in the Kansas–Indian Territory field are so closely connected with those of oil as to be almost inseparable.

About the year 1860 the numerous shallow oil wells drilled to depths of a few hundred feet in southeastern Kansas yielded traces of natural gas as well as of oil, and one producing both gas and salt water was drilled at Iola, about 50 miles northeast of Independence. Twenty years or more later, early in the eighties, gas in small quantities was found in a number of places near Independence. A company formed there for the purpose of mining for coal put down a drill hole in 1884, but instead of coal found natural gas at a depth of 1,200 feet. The gas became ignited, did considerable damage, and was abandoned without any attempt to utilize it, as no one then thought of gas as present in economic quantities. In 1892 a well was drilled on the Westfall place near Paola, Miami County, which produced enough gas to be of commercial importance. Other wells were soon drilled in the

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district and Paola was the first city west of the Mississippi to be supplied with natural gas.

In 1889 gas in moderate quantities was found at Cherryvale and about a year later at Coffeyville, which soon after became the center of the first gas field recognized on the quadrangle. Coffeyville has long been known as a great producer of gas. As generally understood the Coffeyville field is 8 or 10 miles wide. It extends westward beyond Dearing, southward to the State boundary line, and northward probably to the Independence-Dearing field. Originally it was exclusively a gas field, no attention being paid to oil, although some good gas wells passed through shallow oil sands which might have been productive had they been properly treated. The first wells were shallow and the gas pressure correspondingly light. Soon, however, other wells were sunk to depths of 900 to 1,000 feet and a much larger supply of gas was obtained.

Not until 1893 was Independence supplied with gas. Messrs. McBride and Blume were the moving spirits in organizing the Independence Gas Company, which drilled its first gas well in Februaryof that year. Although gas was found and utilized for all manufacturing, heating, and illuminating purposes, its great importance was not realized and for several years the company had the field alone. The gas wells shown on the map (Pl. I) immediately west of Independence are almost all old wells from which the town drew practically its entire gas supply for a number of years. Later the Bolton field was opened and the gas wells south of Bolton were drilled and connected with the main pipe line supplying Independence.

Neodesha has long been recognized as a center of production of gas as well as of oil. The first good gas well in the immediate vicinity of Neodesha was obtained by Guffey & Gailey in 1893. The same year other good wells were drilled about 3 miles northwest of town, in the angle between Verdigris River and the St. Louis and San Francisco Railroad. Gas was piped from these wells into Neodesha, and July 4, 1893, a great celebration was held, during which an oil well was shot during the day and the gas was lighted to make a brilliant illumination at night.

During the latter half of 1901 a large gas well was drilled at Caney, in the extreme southwest corner of the quadrangle, where, soon after, a number of other good wells were brought in.

In the Bolton pool gas wells intimately associated with the oil wells were first obtained occasionally during the season of 1904 and have increased in number up to the present time.

Gas is found also at Wayside, but here it is not so closely associated with oil as in the Bolton pool.

In the Sycamore-Crane area, to the west about Elk, and in the northwestern part of the quadrangle a few gas wells have been drilled, but none of large production.

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OCCURRENCE.

What has been said concerning the occurrence of oil applies also to the occurrence of gas, except that the gas is usually more abundant than the oil and has been found in a larger number of places. As a rule also more gas sands than oil sands are encountered in the drilling of individual wells. The productive sands seem to be uniformly fine grained, as might be expected from their close association with the shales. As has been indicated, in nearly all the fields described the gas wells are intimately associated with the oil wells, and many wells produce both gas and oil. For example, 2 miles east of Caney, in the southeast corner of sec. 8, there is a group of wells of which eight or ten are fair oil wells and three are good gas wells, the latter ranging in production from 15,000 to 20,000 cubic feet per day.

In regard to the relative horizons at which oil and gas occur no definite rule can be laid down. The oil may be found above the gas or below it. In most cases, however, the two are separated by an impervious stratum, usually 30 feet or more in thickness. It is contended by some that the large gas wells south of Independence are connected with and dependent for their supply on the Bolton oil pool, but the occurrence of dry wells at intermediate points militates against this view. It has been reported that gas was encountered in the Caney deep well at depths of 1,850 feet and lower. At present the well is nearly full of salt water, through which gas flows intermittently in fair quantity. The gas is believed to come mainly from depths of 1,800 to 2,300 feet.

CHARACTER AND VALUE.

Of the several gases of which natural gas is a mixture, marsh gas (CH_4) constitutes from 90 to 98 per cent of the Kansas product. The following table shows the composition of the gas at various localities in the Kansas field:

Composition of natural gas in the Kansas field.[a]

	Paola.	Osawatomie.	Iola.	Cherryvale.	Coffeyville.	Independence.	Neodesha.
Carbon dioxide	0.33	0.22	0.90	0.22	0	0.44	1
Olefiant gas, etc	.11	.22	0	0	.35	.67	.22
Oxygen	.45	Trace.	.45	.22	.12	Trace.	.65
Carbon monoxide	.57	1.33	1.23	1.16	.91	.33	.50
Marsh gas	95.20	97.63	89.56	92.46	96.41	95.28	90.56
Nitrogen	2.34	.60	7.76	5.94	2.21	2.28	7.07
	100	100	100	100	100	100	100

[a] Bailey, E. H. S., Kansas Univ. Quart., vol. 4, No. 1, July, 1895, p. 10.

The following prices serve to convey an idea of the local value of the gas. The Cherryville Gas Company, whose leases cover about 75,000 acres and whose pipes extend into the city, supplies gas for domestic use at

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the monthly rates of $1.50 per stove and 10 cents per light for residences, and of $2.50 per stove and 20 cents per light for business purposes; or at the meter rate of 15 cents per 1,000 cubic feet to gas engines, or at 75 cents per 1,000 brick to the Cherryvale Brick Company. The Edgar Zinc Company sells natural gas to the people of Wayside, mostly its own employees, at the rate of $1 per stove and 10 cents per light per month, and the Federal Betterment Company sells to other manufacturing companies at the rate of 60 cents per 1,000 cubic feet. At Independence the Natural Gas Company has entered into an agreement to furnish the Industrial Club of that place with natural gas at the rate of 3 cents per 1,000 cubic feet, a rate that but little exceeds the cost of production. At Rosedale and Kansas City natural-gas rates for manufacturing purposes range from 10 to 12½ cents per 1,000 cubic feet, based on estimated quantities consumed.

DEVELOPMENT.

The history of the development of natural gas practically coincides with that of oil, nearly all the gas having thus far been found in drilling for oil. The areas covered by gas leases, however, are larger than those under oil leases and are likely to become still larger.

The following gas areas, nearly all coinciding with previously described oil areas of the same names, practically represent the region of operation and development in the quadrangle during the summer of 1904.

The Cherryvale area, having a radius of 5 or 6 miles, centers about the town of Cherryvale. Like the Coffeyville area, it has long been known as a gas district. There are many productive gas wells in the eastern part of town and in the adjacent country within a few miles. During the last four years another portion of the area, very rich in gas, from 3 to 6 miles north of town, has been opened. The earliest drilling in the area was done by the Vulcan Mining Company in September, 1889. This enterprise at first met with only moderate success, but before the close of the year enough gas was found to justify piping it for use, and in 1890 and 1891 the supply became sufficient to permit its general use for domestic purposes in the town of Cherryvale.

The Coffeyville area was the first recognized gas field in the quadrangle. It trends north and south, with Coffeyville over its center, extending southward to the Kansas–Indian Territory line and northward 5 or 6 miles beyond the city. A number of the first gas wells were within the city limits, and some of those drilled thirteen years ago are still producing small quantities of gas. The strongest wells in this field at present are those recently sunk in a pool 3 or 4 miles west of Coffeyville, situated on both sides of the Missouri Pacific Railway, along Onion Creek, and extending to the west beyond Dearing. These

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wells produce an enormous quantity of gas. The Dearing district appears to be relatively free from oil, but it is believed that after the gas pressure has diminished oil will become available.

The Independence-Dearing area lies north of the pool just described, between Dearing and Independence and about midway between the Bolton and Coffeyville areas. It is 5 or 6 miles across. It was developed within the year 1904 and contains more large gas wells than any other area in the Kansas field. Some are authentically reported to have produced over 30,000,000 cubic feet per day. Late in November, 1904, one well was bought and paid for on a basis which assumed a production of 33,000,000 cubic feet per day. Nearly all the gas wells east of the Missouri Pacific Railway, between Independence and Jefferson, are new ones and represent the remarkable development of the summer of 1904. This and the adjacent old Bolton gas area, just south of Bolton, with which it is practically connected by a number of large wells that supplied gas to Independence for four or five years, constitute the most remarkable gas field in the State. This field has an output of 70,000,000 cubic feet of gas per day. A 16-inch main is projected to supply gas to all cities within a radius of 150 miles. Gas is furnished to neighboring factories at the rate of 3 cents per 1,000 cubic feet. The content of the field is deemed sufficient to last for half a century.

In a well drilled in the Caney area, 3 miles east of Caney, in the latter part of 1901, an enormous flow of gas was obtained at a depth of almost 1,500 feet. At that time this was the strongest well in the entire Kansas area and was reported to have a static pressure of 600 pounds and a flow of fully 15,000,000 cubic feet per day. Further developments in this field have resulted in the sinking of a moderate number of gas wells, from each of which the yield is unusually large. One well drilled early in 1904 reached a depth of nearly 1,600 feet and produced a flow of gas reported to be nearly 20,000,000 cubic feet per day.

Neodesha has long been known as a center of production of gas as well as of oil in the Kansas field. Excellent gas wells have been drilled here in the outlying areas to the northwest and to the east of town. Those to the northwest, between Verdigris River and the St. Louis and San Francisco Railroad, were the first developed. A very large quantity of gas is found here, particularly in sec. 7. This is the original Neodesha field from which gas was piped by Guffey & Gailey in 1893. Later the wells to the east, in range 17, were brought in and a remarkable gas field was opened, principally by the Prairie Oil and Gas Company. Pipes have been laid from this field to Neodesha and to Parsons, and it now furnishes the principal supply of gas for these two places.

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PRODUCTION.

It is difficult to estimate the quantity of gas produced in the Independence quadrangle. That the production is enormous can be realized from what has been said. The value of the quantity now annually consumed in the quadrangle itself is estimated to be about $800,000.

Owing to the limited funds available for the survey of the Independence quadrangle more detailed observations and gas-pressure measurements of the wells were omitted. So far as observed, however, except that the wells are much larger, the conditions, phenomena, and pressures are similar to those observed by members of the Survey in the adjacent Iola quadrangle in 1903.[a]

UTILIZATION.

Thus far most of the gas has been put to local use. It furnishes the light, fuel, and power of practically all the cities and towns and most of the farm communities and is extensively used for fuel in drilling and pumping. It also supplies the city of Parsons and its numerous industrial plants east of the quadrangle. All this, however, forms but a small percentage of the quantity consumed and to be consumed by the manufacturing industries which have grown out of this natural commodity. Of these industries the most important are those producing brick, tile, pottery, glass, cement, zinc, and lead.

ZINC SMELTING.

The smelting industry has become very important by the importation of large quantities of ore from the Joplin district in order to make use of the gas in extracting the metal zinc. There are large smelting plants at Cherryvale, Neodesha, and Caney, all of which use natural gas for fuel.

Zinc has a great affinity for other elements. It is therefore difficult to release its hold on both sulphur and oxygen. A large and costly calcining furnace is necessary for the first process and an equally large and costly separating or reduction furnace for the second. The simplest style of roasting furnace is one built with the intake for fuel at one extremity and the ore feeder at the other. The ore rests upon a fire-brick hearth, where it is heated to redness by the flames passing over it. If there is an excess of oxygen in the flame the ore will become oxidized. The sulphur oxidizes to a gaseous product and passes up the smokestack and the zinc remains behind in the form of zinc oxide.

After the ore is thoroughly oxidized it is drawn from the calcining furnace and transported to what is usually called the reducing or retort furnace. This furnace is built so that two tiers of reducing

[a] Bull. U. S. Geol. Survey No. 238, 1904, pp. 43-63.

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retorts may be held in position end to end, each tier consisting of from four to six horizontal rows one above another, with the retorts varying greatly in number. Each retort is about 10 inches in internal diameter, 4 feet long, and cylindrical in shape. In the old-fashioned coal furnace the length of retort rows was limited, as the smokestack was located at one end and the fire box at the other. It was necessary for the flame and heat from the fire box to pass entirely over the retorts. Hence, if the smokestack was too far removed the retorts near it were not sufficiently heated. The old-fashioned coal furnace sometimes had not more than 16 retorts in a row, but with increased draft the number might be enlarged to 32. If a side or tier of the furnace had five rows, this would give 160 retorts to each side, or 320 to the furnace. In Kansas it is customary to speak of each tier as a furnace and of the two built together as a block, so that such a 320-retort furnace would generally be described in Kansas as containing two furnaces of 160 retorts each, or as being a 320-retort block. The retort furnaces for using gas as fuel may be made of any desirable length. The gas is admitted at intervals along each side at any point where it seems best.

Natural gas is principally composed of marsh gas, CH_4. For the proper combustion of marsh gas so that all its heat equivalent may be obtained, chemical action should take place according to the formula $CH_4+4O=CO_2+2H_2O$. By volume, one molecule of CH_4 would occupy only one-half as much space as 4O or $2O_2$. The ratio required for complete combustion therefore is 2 volumes of oxgyen to 1 of marsh gas, each being under the same conditions of temperature and pressure. But as the atmosphere is only about one-fifth oxygen, in order to get 2 volumes of oxygen it is necessary to have 10 volumes of air. Hence to have complete combustion of natural gas 1 volume of the gas should be mixed with 10 volumes of air. As the mixture may not be complete, a slight excess of air is desirable to guarantee complete combustion, and the furnaces are arranged to admit about 11 volumes of air to 1 volume of natural gas. The air is forced through the intake pipes by fans.

By a proper distribution of the intakes for gas and air a retort furnace using gas as fuel may be heated more uniformly and the temperature maintained with a greater regularity than is possible in the old-fashioned coal furnace. The impression that gas smelters do not yield quite as high a proportion of spelter from ore as coal furnaces seems to be without foundation. In fact the use of gas is so satisfactory that the company at Cherryvale contemplates manufacturing gas from coal and using the artificial product in its plant whenever the supply of natural gas gives out.

The smelter at Cherryvale, which began operations in June, 1899, uses 3,600 retorts. The plant is excellently built, uses the patented

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Brown roasting furnace and the ordinary Belgian furnaces for reducing zinc oxide, and has very tall smokestacks, which carry the sulphur fumes so high above the ground that they become sufficiently diffused in the air to prevent deleterious effects on near-by vegetation. It has been in continuous operation since its first installation and has produced a large quantity of high-grade spelter. The ores are imported from the Joplin district, where this company is one of the principal buyers. The company early secured a fair number of leases and drilled many good gas wells before it began to build its plant. Later it acquired many new leases and continued to drill, so that at present it holds thousands of acres of excellent gas land and has large quantities of gas far in excess of its present requirements.

In 1902 a small zinc smelter consisting of four blocks was established at Neodesha by the Lanyon Brothers Spelter Company. Early in 1903 the Granby Mining and Smelting Company bought this plant and began to enlarge it at once, and has continued to increase its size intermittently up to the present time. It now contains 8 furnaces of 320 retorts, or 4 blocks of 640 retorts each—a total of 2,560 retorts in use. The Granby Company has a fair amount of gas land and also holds a contract with the city of Neodesha, by the terms of which it is supplied with whatever gas it needs at the rate of 3 cents per 1,000 cubic feet. The city waterworks also furnish it with water at 3 cents per 1,000 gallons.

The large zinc smelter operated at Caney was built in 1903.

GLASS FACTORIES.

There are nine glass plants within the area of the Independence quadrangle—six at Coffeyville and one each at Independence, Cherryvale, and Caney. Of those at Coffeyville the Kansas Window Glass Company, the Coffeyville Window Glass Company, and the Sunflower Window Glass Company manufacture window glass; the Marion Fruit Jar Company makes fruit jars, turning out about 500 gross per day; the Coffeyville Bottling and Glass Company makes bottles at the rate of 2½ carloads per week, and the Pioneer Flint Glass Company makes tableware, lantern chimneys, etc. The plant at Independence manufactures window glass, that at Cherryvale makes decorative tableware, barroom ware, etc., and that at Caney a variety of glasswares. The total capacity of the window-glass factories is about 12 carloads per week for the time during which they are in operation.

In some respects the operations of all these plants are similar. All use natural gas for fuel, all import their sand from Missouri or from Illinois and their soda cake from the works of the United Zinc and Chemical Company at Kansas City, and all shut down during the hottest summer weather, as do similar plants elsewhere in the United States.

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Another large glass factory is being erected at Fredonia, just north of the Independence quadrangle, which expects to procure its sand from the sandstone occurring near the middle of the Buxton formation, a few miles west of Fredonia.

EXPORT.

Early in the season of 1904 strenuous efforts began to be made by the Kansas Natural Gas Company to pipe gas for manufacturing and other purposes from the Independence quadrangle and other parts of the Kansas field to Kansas City and intermediate points. Though the measure met with opposition on the part of the citizens, who realized that the industrial life of the community was largely dependent on the home consumption of this natural commodity, it finally became successful. The pipe line was laid and is now in operation via Joplin, Mo., and on its way northward to Kansas City supplies Garnett, Lawrence, Topeka, and numerous smaller places with gas.

NEED OF ECONOMY.

"Husband the gas" is the advice of experienced Pennsylvania men who visit the Kansas field and note the great waste of gas there. In some eastern fields the use of natural gas for manufacturing purposes is not allowed, while in others the manufacturers are taught to regard it as a great luxury. The urgent advice of these men is that in the Kansas-Indian Territory field the gas should be reserved as a luxury for domestic use and that in no area where there is a prospect that the supply may soon become exhausted should it be used for industrial purposes, for a single one of the large manufacturing plants consumes gas enough to supply a whole city. That the quantity consumed by these plants is very large may be inferred from the fact that a plant of any considerable size usually keeps several drills in constant operation to replenish its gas supply as the older wells one after another give out.

During the last few years there has been a lamentable waste of gas in the Kansas field through delay or neglect to cap wells and to turn off lights and torches, many of which were left to burn day and night the year round. Recently, however, Kansas has passed a State law prohibiting all unlawful waste of gas, and officials are at work in the field seeing that the law is enforced.

FUTURE PROSPECTS.

What has been said concerning the future prospects of oil in the Kansas-Indian Territory field (p. 39) applies equally well to gas. It should always be borne in mind by both producers and users of gas, as well as of oil, that the quantity stored in a given territory is necessarily limited and that once exhausted it will not be replaced.

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COAL.

IN THE WILSON FORMATION.

GENERAL STATEMENT.

In the early seventies coal was found in beds outcropping near Independence and two companies were organized to develop it, but neither met with success. In 1884 drilling was resumed and a coal bed of good quality was found, but it was at too great depth to be mined with profit. Subsequently, the same beds of coal as those outcropping at Independence or similar beds were discovered at other points both northwest and south of Independence, and now several workable beds of bituminous coal are known to outcrop in the quadrangle. These beds, however, nowhere exceed 2½ feet in aggregate thickness, and the average thickness for all localities is probably less than a foot. The beds are exposed at intervals in a belt some 5 to 10 miles in width, extending diagonally across the quadrangle from about its northeast corner nearly to the southern edge. They occur in the upper part of the Chanute shale member of the Wilson formation near the Iola limestone horizon and are the lowest coal beds in the upper Coal Measures that occur in sufficient quantity to be of any considerable importance. They lie nearly flat, being conformable with the rocks in which they occur.

Though the coal is not found in sufficient quantity for shipment, ever since pioneer times it has supplied local communities and rural districts with fuel, and some of them still use it, particularly where fuel gas has not been introduced. The regions in which the coals are best exposed and have been most developed may be described, from northeast to southwest, under the headings of Chetopa Creek, Brooks, Sycamore, Independence, and Jefferson districts.

CHETOPA CREEK DISTRICT.

The most important coal beds of the quadrangle are those outcropping on Chetopa Creek, in the northeast corner, approximately between Neodesha and Thayer, Neosho County, whence they are commonly known as the Chetopa Creek–Thayer and Neodesha-Thayer coals. The best of these beds are found in what is known more particularly as the Thayer field, an east-west rectangular area of about 15 square miles at the head of Chetopa Creek, in the extreme northeast corner of the quadrangle, its eastern edge being about 3 miles west of Thayer; and the most important bed is that of Coal Hollow, a south-side head branch of Chetopa Creek, in the northwest corner of Shiloh Township, 3 to 4 miles southwest of Thayer. The coal produced here is the typical Thayer coal and is the best grade of any outcropping on the quadrangle. At a point 3¾ miles

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west of Thayer the coal is again exposed in two beds, which are, respectively, 2 inches and 10 inches in thickness, separated by 8 inches of clay. Three-eighths of a mile farther west, as shown in two open pits that have been productive for many years and are now being worked, the coal occurs in a single bed 1½ feet in thickness. Apparently this same bed is again exposed 2 miles farther west, in the east bluff of the north branch of Chetopa Creek, where it maintains its thickness of 1½ feet, and is overlain by calcareous sandstone and shale and underlain by 8 feet of arenaceous shale resting upon a thin limestone conglomerate. Five-eighths of a mile southwest of this point, at what is known as the Scott coal bank, the coal again occurs in two beds, as shown in the following section:

Section at Scott coal bank, Wilson County, Kans.

	Inches.
Limestone, lentils	12
Coal, good quality	10–12
Shale	6–10
Coal, good quality	8
Shale, arenaceous.	

To the southwest from the Scott coal bank, down Chetopa Creek and in its vicinity, the coal outcrops at many points, showing the bed in that region to vary from 10 to 18 inches in thickness. At the Verdigris River highway bridge, just east of Neodesha, it is 10 inches thick.

BROOKS DISTRICT.

The Brooks district is situated about 6 miles southwest of the Chetopa Creek district, mostly on the drainage of Dry Creek, and extends across the southern portion of Newark Township, about a mile north of Brooks. Here, as shown in an exposure 1 mile north and one-half mile west of Brooks, in the bend of the railway, the coal occurs in a bed 8 to 12 inches thick. It is of good quality and is locally used for domestic purposes, but has not been worked extensively at any locality. It is nearly everywhere directly overlain by sandstone and shale.

SYCAMORE DISTRICT.

Coal is also exposed at several points in the Verdigris River bluffs about 2 miles east and northeast of Sycamore. At some of these the coal has been worked and is reported to be of good quality, but the bed so far as observed does not much exceed 6 inches in thickness.

INDEPENDENCE DISTRICT.

The Independence district extends from the north edge of Independence Township, near the mouth of Elk River, southward along the west side of Verdigris River, beyond Coal Creek a distance of

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7 miles. Independence is situated in its northern part. The most important localities are at points a mile northeast and 1 to 2 miles southeast of Independence and in the southern part of the district, mostly in the Coal Creek drainage.

The first-mentioned locality, about a mile northeast of Independence, is practically on the banks of Verdigris River, in a ravine almost between the river and the cemetery. The coal bed here is 1 to 2 feet thick and, as shown in five or six pits, where the coal has been mined for local commercial purposes, is capped by an arenaceous limestone overlain by sandstone; but one-fourth to one-half mile farther north, where likewise a number of pits have been opened, the roof is a pure sandstone, which still farther north becomes massive.

To the south this or a similar coal bed underlies the city of Independence and outcrops in some localities. It has a thickness of 12 to 14 inches. Here and there it is represented by black slate. One block west of the Carl-Leon Hotel the city pipe-line excavation has exposed this bed 6 feet below the surface.

One and one-fourth miles southeast of Independence, in the north face of the sandstone hill south of Rock Creek, the bed is 18 inches thick and the coal is of good quality. Here it lies between two shale beds, each 30 to 40 feet thick. About 45 feet below this seam occurs 12 inches of black bituminous shale, corresponding with a coal bed exposed in the northwest base of the hill, which seems to be the same bed that, according to reports, has been mined to a considerable extent farther west, a mile or two southwest of Independence.

In the locality along Coal Creek, 4 to 5 miles south of Independence, the bed is 12 to 20 inches thick, and the coal is of good quality, but contains a couple of thin seams or partings of blue shale, which cause some waste in mining. It was formerly mined and used at Independence. At the head of Coal Creek the roof is blue shale and the floor is bluish-gray fire clay, while 2 miles to the northeast the roof is sandy shale and sandstone. The bed is here 14 inches thick, including a 2-inch seam of slate. Considerable mining was done here by the stripping method as early as ten years ago, the output being used at Independence and in the surrounding country.

JEFFERSON DISTRICT.

The Jefferson district is near the middle of the southern half of the quadrangle, in the northern part of Fawn Creek Township, near Jefferson, a village on the Missouri Pacific Railway, 8 miles south of Independence. The producing bed is the same as that on Coal Creek. It has been mined south and southeast of Jefferson, the more important localities being described in the following paragraphs:

In the basal slope of the hill south of Onion Creek, 1¼ miles south of Jefferson, the coal bed is exposed 1 foot thick. It passes down-

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ward into black shale and is overlain by a heavy 3-foot layer of sandstone, whose lower 2 to 3 inches next the coal forms a soft shaly roof, while upward it passes into 30 to 40 feet of heavy-bedded reddish-brown sandstone, good for masonry.

One and three-fourths miles farther south, about 3 miles south of Jefferson, on Fawn Creek, and particularly along one of its tributaries, on what is known as the Messersmith farm, the bed, including two very thin seams of shaly slate, is 16 inches thick. The large number of old dumps and tunnels show that it was somewhat extensively mined in the past, one tunnel having been driven a distance of 175 feet and each of several others about 50 feet. Until the discovery of natural gas the coal was constantly used for domestic, thrashing, and schoolhouse purposes, and sold at 10 to 15 cents per bushel. Between the coal and the sandstone covering a bed of coaly shale is sometimes, though not always, present, and the under clay is reported to consist of 6 feet of shale, which in turn rests on blue sandstone.

One mile south and 3¾ miles east of Jefferson, on the farm of Henry Bowen, the same coal bed was extensively mined before gas came so prominently into use in this region. The country rock is sandstone and shale. The coal in this locality is reported to occur principally in sandstone, at depths of 6 to 12 or 15 feet below the surface, and to consist of three beds, aggregating about a foot in thickness, the top bed being 7 to 8 inches and the other two each 2 to 3 inches. The beds are separated from each other by an inch or two of unctuous shale or shaly clay. Most of the coal lies too deep for stripping and the beds are too thin to be mined underground. The coal formerly sold for 10 cents a bushel, mainly for domestic use. It has also been used in blacksmithing, but not satisfactorily, as it soon air slacks on exposure. It is reported to be of two kinds, commonly known as black and red. The red is the better heater.

OTHER SHALLOW COAL BEDS.

Thinner nonworkable coal beds also outcrop in shales other than those of the Wilson formation, notably in the upper part of the Coffeyville formation. The Buxton formation is known to contain beds of workable coal, but no beds of this class were observed in it in the Independence quadrangle. Similar exposures of coal beds were noted to the east, in the Parsons quadrangle, particularly on Big Hill Creek, and one-half mile east of Mortimer.

DEEP-SEATED COAL.

In drilling wells deep-seated coals are encountered at varying depths from place to place within the limits of the quadrangle, the most important being found in the Cherokee shales, which contain the largest beds of workable coal found in the State, the Weir-Pittsburg

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and others. Drill records from 4 miles south of Independence report such a bed of good coal 4 feet thick at a depth of 600 feet below the surface. The well drilled on the Linscott farm, 1 mile farther south, is reported to pass through a 14-foot bed of excellent coal at a depth of 1,100 feet. The same or a similar bed is reported to occur in the vicinity of Sycamore, in the northern half of the quadrangle. This may be regarded in a general way as the bed represented in the upper part of the Cherokee shales in the general columnar section (Pl. III, p. 10). Thinner and less important deep-lying beds are encountered at various depths, as shown in the Neodesha and other deep-well logs (p. 30 et seq.).

STONE.

FOUNDATION AND BUILDING STONE.

The stone at present used for constructional purposes in this quadrangle is derived mostly from the sandstone occurring in the Chanute and Concreto members of the Wilson formation and in the Buxton formation and from the Drum limestone. Probably four-fifths of the quantity used is sandstone. As shown in Pl. I (pocket), quarries are opened near the cities and towns and at many intermediate points.

The building stone used at Independence and Neodesha is almost wholly sandstone. The Went quarry, 2 miles north of Independence, has been in active operation for many years, has a large output, and supplies most of the stone for Independence and the surrounding country. The quarry is on the level prairie land near the Missouri Pacific Railway, and two other quarries are located near by. The main pit of the quarry is about 225 feet square and 15 feet deep, its faces exposing 10 to 12 feet of good rock beneath a covering of 3 to 4 feet of surface soil and thin shaly sandstone. The beds lie nearly horizontal, the dip being gently north, with slight warping indicated at one or two points. The section of useful stone now being worked consists of layers varying from 3 or 4 inches in thickness at the top to 2½ feet at the bottom of the quarry. The rock is remarkably fine and even grained, slightly micaceous, and of pale brownish-gray color with often a greenish tinge. A prospect hole sunk in the bottom of the quarry encountered a bluish sandstone in two layers of 10 inches and 5 feet in thickness, respectively, each giving promise of economic value. These data, in connection with the log of a near-by well, indicate for this locality a total thickness of about 50 feet of a good grade of workable stone. The stone is easily quarried and dressed and is taken out in all sizes, the thicker blocks being used for foundation and building purposes and the thinner for sills, caps, steps, curbing, and paving. A number of handsome residences and churches are built of

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it, and in some of these it has been ornamentally cut, but the cutters report that owing to the fact that it is "plucky" in spots extra care is required in trimming it for fine work. It sells for $2.65 and upward per perch.

At present the most important source of constructional limestone is in the upper member of the Drum formation, in a narrow belt 2 to 3 miles northwest and west of Coffeyville, extending from Reservoir Hill southwestward beyond Dearing, thence southeastward along Onion Creek to the State line. The rock is mostly hard blue limestone, at some places flinty. It is thinner bedded than the sandstone just described, but dresses well. As in the case of the sandstone at Independence and elsewhere the heavier pieces are used principally for footing, foundation, and building purposes, while the thinner pieces, 3 to 5 inches thick, make excellent flagging, paving, and curbstones. Some of the quarries, notably those of Albert Short, 3½ miles northwest of Coffeyville, also supply limestone for fluxing purposes to nearly all the glass factories of Coffeyville. The foundation and building stone sells for $1.25 per perch, or about $10 per cord, in competition with brick that can be used for the same purpose.

Of the five or six quarries in the district the Gorton quarry, on the south side of Onion Creek, 3½ miles west of Coffeyville, furnishes a fair average section of the useful rock. The rocks in all cases lie nearly flat.

Partial section of Drum formation exposed in W. H. Gorton's limestone quarry, Montgomery County, Kans.

	Ft.	In.
Surface soil		9
Shale, in part weathered	3	
Limetsone, hard, blue, flag		4
Seamy parting		1
Limestone, hard, blue		9
Limestone, seamy		1
Limestone, hard, blue		6–7
Seamy parting		1
Limestone, hard, blue		11
Limestone, seamy		2
Limestone, hard, blue		4–5
Shale	3+	

There is reason to believe that other districts in the quadrangle may produce stone as good and as abundant as at Independence and Coffeyville. The sandstone deposits in the Liberty region east of Big Hill Creek have supplied practically all the building and paving stone for Liberty and have recently furnished the abutments for the new steel bridge built across Pumpkin Creek. The map (Pl. I, pocket) shows in a general way where the rocks have been most quarried and the distribution of the formations in which the quarries occur.

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FLAG, CURB, AND PAVING STONE.

Stone of good quality for flagging, curbing, and paving is abundantly supplied from the thinner layers, 3 to 10 inches thick, in the quarries at Independence, Coffeyville, and elsewhere. The large slab in front of the Commercial Bank at Independence, taken from the Went quarry, is approximately 16 feet wide, 24 feet long, and 9 inches thick, and weighs about 18 tons. For paving the Independence sandstone is reported by Mr. J. Phelan, city engineer of Independence, to be cheaper than concrete, but not so good, since it wears unevenly, for which reason, together with its porosity, the stone would probably not last long in a moist climate subject to frequent extremes of cold and heat.

MACADAM AND BALLAST.

At Independence the Drum limestone is crushed by the city for macadam purposes; at Cherryvale and Morehead it is crushed and exported for ballast by the Atchison, Topeka and Santa Fe Railway. Limestone equally suitable for street and road purposes occurs also at Neodesha, Elk, and Coffeyville.

LIME.

Though the industry of manufacturing lime is not now carried on within the limits of the quadrangle, the presence of numerous old kilns and statements from settlers show that all the more important limestones of the quadrangle have been utilized for burning lime. As shown in Pl. I (pocket), these are the Piqua limestone at and northwest of Table Mound, the Drum limestone east of Independence, and the Dennis limestone northeast of Cherryvale. The Allen limestone in the northern part of the quadrangle, on Fall River, would also probably prove suitable for the purpose.

GLASS SAND.

At a number of localities along the western side of the quadrangle sandstone occurs in the Buxton formation in bodies of from one-eighth to one-half mile in extent of such purity, fineness, and evenness of grain as to give promise of usefulness in the manufacture of glass. Exposures occur 4 miles northwest and 2 miles north of Caney. At the latter locality the long hill is capped by sandstone at least 10 feet thick. Other exposures occur farther north. Perhaps the best is in the southern part of Fall River Township, in the SE. ¼ sec. 22, about 4 miles southwest of Fredonia. Here the rock is exposed over an area of 10 or 15 acres and appears to be about 12 feet in thickness.

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PORTLAND-CEMENT MATERIALS.

GENERAL STATEMENT.

The area of the Independence quadrangle, principally its northern part, bids fair to become, in the near future, the home of important Portland-cement industries. Already two large plants are in process of construction—one at Independence, by the Western States Portland Cement Company, and one at Neodesha, by the American Portland Cement Company. The abundance of natural gas available for fuel and of good limestone and shale, together with the regularity in the composition of the limestone, render this field a very attractive one to cement manufacturers. The Kansas State Geological Survey has published a brief report on the cement materials in this area.[a]

A good Portland cement may be made from a limestone low in magnesia and carrying from 75 to 100 per cent calcium carbonate by mixing it in proper proportions with clay or clay shale. A limestone having from 85 to 90 per cent calcium carbonate may be, therefore, just as desirable as one theoretically pure. The clay and clay shales may have a high proportion of lime present, as many of the Kansas shales do, and still be very desirable, for the lime in the shale will serve the same purpose as the lime in the limestone. The main features to guard against are too large an amount of magnesia or sulphur and a combined amount of alumina and iron oxide greater than one-half the silica.

CHARACTER AND DISTRIBUTION.

The materials suitable for making Portland cement in this area are practically identical with those existing so abundantly within the Iola quadrangle, described in a former bulletin of the Survey.[b] Their distribution in the Independence and adjacent quadrangles is shown on the maps (Pls. I and II).

The plant at Independence is located 1½ miles southeast of town, near the mouth of Rock Creek and Verdigris River. It is built on the Drum limestone, which here attains a thickness of nearly 100 feet and outcrops over an area of several square miles. It is massive or heavy bedded, semicrystalline, medium to coarse grained, and fossiliferous. It has been tested by the company and found to be satisfactory, analysis showing it to be a very pure lime carbonate. Shale of good quality overlies the limestone; fuel is obtained from the gas wells near by and water from Verdigris River. The plant will use the dry process and will have a capacity of 2,500 barrels per day. It is to be run by electric motors driven by steam power generated by gas. The company holds leases on about 1,200 acres of gas land, and now

[a] Ann. Bull. on Mineral Resources, Univ. Geol. Survey, Kansas, 1902, pp. 45–56.
[b] Bull. U. S. Geol. Survey No. 238, 1904, pp. 63–69.

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has five good gas wells ranging in production from 15,000,000 to 20,000,000 cubic feet per twenty-four hours. The plant is connected with the Missouri Pacific Railway by 3 miles of branch line built during the summer of 1904.

At Neodesha the limestone to be used for cement is the Allen limestone which caps the hill known as Little Bear Mound about a mile northwest of town, where it has been found to have a thickness of 55 to 70 feet. Suitable shale is present underneath the limestone and an abundance of oil and gas for fuel purposes is available. The company holds a contract with the city of Neodesha to be supplied with natural gas from the city mains at 3 cents per 1,000 cubic feet.

Analyses of the limestone and shale at Neodesha are as follows:

Analysis of Allen limestone at Neodesha, Kans.[a]

Silica (SiO_2) and insoluble matter	3.11	Magnesia (MgO)	Trace.
Alumina and iron oxide ($Al_2O_3+Fe_2O_3$)	1.06	Sulphuric anhydride (SO_3)	None.
Lime (CaO)	52.40=93.58 $CaCO_3$.	Loss on ignition	42.45

Analysis of Concreto shale at Neodesha, Kans.[a]

Silica (SiO_2)	50.80	Magnesia (MgO)	2.19
Alumina (Al_2O_3)	16.75	Sulphuric anhydride (SO_3)	None.
Iron oxide (Fe_2O_3)	4.83	Loss on ignition	12.24
Lime (CaO)	8.83=15.7 $CaCO_3$.		

Sufficient chemical examinations have been made in different localities to justify the statement that the Allen limestone retains a uniform chemical composition wherever found within the northern part of the Independence quadrangle. It is exposed principally near the middle of the northern edge of the quadrangle between Neodesha and Fredonia, mainly in the scarps of Verdigris and Fall rivers. Along Fall River it outcrops in a belt about one-half mile in maximum width on either side.

The erection of a third cement plant at the west base of Table Mound on the bank of Elk River is reported to be in contemplation. Here the principal limestone is the Piqua. It is abundant, and the supply of shale, water, and gas is also plentiful. The section of the useful rocks exposed here consists of 45 feet of pure crystalline Piqua limestone overlying an 80-foot bed of Vilas shale, which in turn rests upon a 5-foot bed of Allen limestone, underlain by 40 or more feet of Concreto shale. The Piqua occurring here probably represents the most important and abundant Portland-cement limestone in the quadrangle. Its area of outcrop useful for cement purposes is about 140 square miles, extending from Table Mound westward to Elk and from Elk River northward beyond the limits of the quadrangle. Throughout this extent, particularly along its eastern edge, where it caps the scarps of Fall and Verdigris rivers, it is easily available, and

[a] Ann. Bull. Mineral Resources, Univ. Geol. Survey, Kansas, 1902.

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in most cases gravity can be used in handling it. Both the Piqua and the Iola limestones are remarkably persistent over wide areas in the State, and they are everywhere likely to be suitable for making Portland cement. Specimens of Piqua limestone taken at a number of places northwest of the quadrangle have been analyzed with the following results:

Analyses of Piqua limestone from Kansas.[a]

Town.	Silica.	Oxide of iron and alumina.	Calcium carbonate.	Magnesium carbonate.	Sulphates.	Moisture.	Total.
Vilas	2.02	2.65	96.07	0.10	.....	.....	100.84
Ottawa	8.00	1.35	90.00	.12	0.02	.....	99.49
Greeley	1.18	3.09	92.71	2.64	.....	.....	99.62
Lane	1.18	2.38	94.77	1.07	.....	.....	99.40
Do	3.82	.77	94.21	1.30	.....	.....	100.10
Do	3.84	1.20	93.61	1.20	.....	.....	99.95
Do	4.79	1.18	93.30	1.26	.....	.....	100.53
Garnett	4.30	.81	92.76	.95	.23	0.43	99.48
Do	.61	.51	97.32	.32	.43	.....	99.19

[a] Ann. Bull. Mineral Resources, Univ. Geol. Survey, Kansas, 1902.

West of Chanute an examination has been made of the same limestone with a view of locating a Portland-cement factory at that place. The results were reported to be entirely satisfactory.

As is usually the case, the shales to be used at Independence and Neodesha are more variable in nature than the limestones. In places they change rapidly in character, principally by a variation in the quantity of sand present. The calcium carbonate also is exceedingly variable, ranging from almost 20 per cent down to a very small quantity; but with these variations the proportions of magnesia and of the alkalies remain fairly constant, and in no case has an excessive amount of magnesium carbonate been found. The following are analyses of shale from different localities in Montgomery and adjacent counties:

Analyses of shale from Montgomery and adjacent counties, Kansas.[a]

Location.	Silica (SiO_2).	Alumina and iron oxide ($Al_2O_3 + Fe_2O_3$).	Lime (CaO).	Magnesia (MgO).	Alkalies ($Na_2O + K_2O$).	Water (H_2O).
Iola	55.002	24.367	0.77	3.30	2.106	7.709
Neodesha	61.80	22.7	8.20	0.216	Trace.	7.50
Coffeyville	64.62	21.82	2.50	0.43	4.15	5.01
Near Iola	57.20	26.80	5.40	3.10	3.90	7.00
Neodesha	50.80	21.58	8.87	2.19	.....	5.37

[a] Ann. Bull. Mineral Resources, Univ. Geol. Survey, Kansas, 1902.

A considerable extension of the Portland-cement industry may be expected in this part of eastern Kansas, though of course each new plant decreases the profits in the manufacture of this product in this area. The limestone and shale used at these plants are plentiful and wholly satisfactory, but the real basis of the Kansas cement industry is the abundant supply of cheap natural gas.

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CLAY RESOURCES.

GENERAL STATEMENT.

The clay resources of the quadrangle consist of numerous beds of shale, some of which attain a thickness of 80 feet or more and are exposed over areas aggregating many square miles. At present the most important and most extensively developed beds are those at Buxton, Caney, Buff Mound, Neodesha, Sycamore, Table Mound, Independence, Tyro, Cherryvale, Coffeyville, and northwest of Coffeyville. The abundance of these shales and of natural gas renders the region peculiarly favorable for the development of clay industries, which include the manufacture of brick, roofing tile, and pottery.

CLAY INDUSTRIES AND PRODUCTS.

BRICK.

General statement.—Brick making is one of the most important industries of the quadrangle. The plants now working produce about 75,000,000 brick a year, and have a capacity considerably greater than that. Twelve companies conduct active operations at Coffeyville, Cherryvale, Independence, Caney, Sycamore, Neodesha, and Buff Mound.

At Coffeyville there are three plants operated by as many different companies. Of these companies the Coffeyville Vitrified Brick and Tile Company, a corporation having plants in a number of places in Kansas and Indian Territory, operates a plant at Independence also. The two other plants at Coffeyville are owned by the Coffeyville Shale Brick Company and the Coffeyville Pressed and Paving Brick Company. The plant at Caney belongs to the Caney Brick Company and that at Sycamore to the Pittsburg Vitrified and Paving Brick Company. Just north of the Sycamore plant is that of the Neodesha Brick Company. At Cherryvale five plants are operated by as many different companies, namely, the Cherryvale Brick Company, at the first mound south of town; the Crown Brick Company, at the extreme west end of the same mound; the Union Brick Company, at the foot of a mound 3 miles south of Cherryvale—a new plant which began operations about October, 1904; the Federal Betterment Brick Company, at the foot of a mound northwest of town; and the Southwestern Brick Company, also located northwest of town. The Altoona Brick Company's plant is at the west base of Buff Mound, 4 miles north of Neodesha.

The material used at all these plants is practically the same, being Coal Measures shales. The plant at the southern edge of Coffeyville uses shale from the Parsons formation; the two plants northwest of town use shale from the Ladore-Dudley member of the Coffeyville

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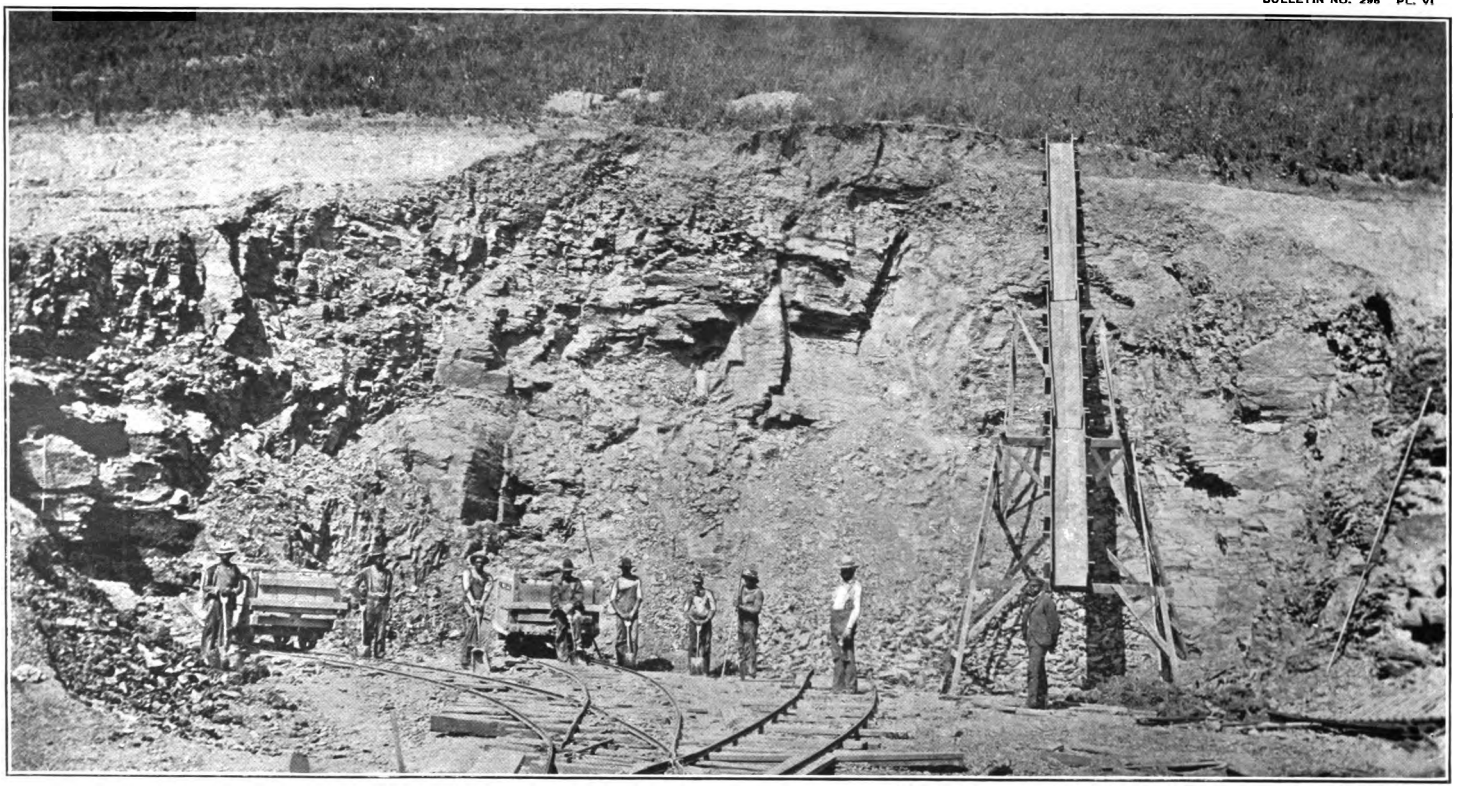

SHALE PIT OF NEODESHA COMPANY'S BRICK PLANT.

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formation, which overlies the Parsons. This overlying shale also supplies the plant at Mound Valley, 5 miles east of the Independence quadrangle. At Cherryvale the five plants use the Cherryvale shale, which occurs in the mounds so numerous in that locality.

At Independence the brick plant is in the northwestern part of town, and the shale is brought by the Santa Fe Railway from Table Mound, on the banks of Elk River 4½ miles to the northwest, where the bed has a thickness of 80 feet. At Sycamore the plant stands north of town, and about midway between Sycamore and Neodesha is the Neodesha plant (Pl. VI); both of these plants use the same shale and are located on the eastern side of the scarp from which the shale is quarried. This shale is also used by the Altoona plant at Buff Mound, where the bed has a thickness of 60 feet. The pits of the Sycamore, Neodesha, Altoona, and Independence plants are all excavated in the upper part of the Concreto shale, just below the Allen limestone. At Caney the Buxton shale is used. The plant is north of town at the foot of a large mound from which the shale is obtained.

All the plants in the quadrangle make brick from practically the same grade of shale, which is quarried, crushed, tempered, and molded in substantially the same manner. The chief product is common building brick. Next in abundance are vitrified brick, or pavers, followed by sidewalk brick and the different styles of dry-pressed or re-pressed ornamental brick.

Common brick.—In the manufacture of common building brick the shale is ground to a fine powder, is sufficiently tempered with water to make a nice mold, and is then forced through a die by auger motion. The rod or mass of clay forced out is carried by a belt conveyor to a proper distance and cut into brick by machinery.

The kilns usually employed for burning common building brick are rectangular in shape and have permanent side walls built of brick to a height of 10 to 14 feet. Suitable openings are left along the sides at the ground for gas pipes to be introduced. The unburned brick are built up in such a manner that air and gas can readily pass between them throughout the kiln. When a kiln is finally charged, a temporary covering of brick is put over it, which is removed when unloading begins.

The kilns are placed from 6 to 10 feet apart, and are built in rows, so that they may be supplied with gas by lateral pipes which tap a common main laid on the surface of the ground between the rows. A large Bunsen burner attachment is placed at the kiln end of the lateral, so that the quantity of air mixed with the gas is well regulated. The size of the opening into the kiln is also so regulated by temporarily closing it to any extent desired that a proper quantity of air is admitted through the opening in the wall itself in addition to what enters through the Bunsen burner. It usually requires from

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six to nine days' firing to burn such a kiln of brick and from three to five days for the mass to cool after the gas is shut off.

The methods employed in unloading the kilns differ locally, the most common one being by means of a metallic wheelbarrow. At some plants the brick are loaded directly on freight cars at the end of the kiln; at others they are piled on the ground to await shipment. Owing to the iron oxides in the shale used, all the building brick in the quadrangle burn to a uniform red.

The Federal Betterment Company at Cherryvale is manufacturing what it calls common building brick, but it uses the dry press and in reality makes a product containing a fair proportion of face brick. At present this company wholesales its entire output to the Coffeyville Brick Company and ships it indiscriminately without any sorting whatever.

Vitrified brick.—Thus far the demand for building brick has been so great that some of the companies have confined themselves to this product and have not made vitrified or paving brick, though the latter are made by all the larger companies. The only essential difference in the processes of making building brick and paving brick is in the firing. Paving brick require a much higher temperature than building brick—a temperature that will bring the entire mass to a state of incipient fusion and hold it at that point for a certain length of time to permit it to become semifused or plastic throughout. To accomplish this a special style of kiln is necessary. The one usually employed is some form of the circular down-draft kiln, with a low dome-shaped roof and open draft spaces connecting the floor with the chimney. Gas mixed with air is admitted at the sides in the method already described for rectangular kilns. On entering the kiln the gas is deflected upward to the concave roof and then downward through the mass of brick to the openings in the floor and out through proper conduits and chimneys. It usually requires about two days' longer firing to burn a kiln of vitrified brick than one of common brick.

Dry-pressed brick.—The essential differences in the methods of manufacturing common building brick and dry-pressed brick are the quantity of water used and the enormous pressure to which the latter are subjected. For molding common building and vitrified brick sufficient water is added to produce a stiff mud, but for dry-pressed brick the quantity of water added is so small that it can scarcely be noticed in the clay.

The operations of the Federal Betterment Company at Cherryvale show that where there is no culling or discarding dry-pressed brick can be placed on the market almost as cheaply as other kinds.

Of the plants enumerated, eight produce dry-pressed brick—two each at Cherryvale and Coffeyville and those at Independence, Caney,

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Sycamore, and Buff Mound, near Altoona. The Buff Mound plant makes a high-grade pressed brick.

Many different kinds of machines have been patented and are on the market for producing dry-pressed brick. All of them employ the same principle, namely, that of a strong metallic mold closed on five sides, with a piston or plunger neatly fitting into the opening on the sixth side. After the mold is filled with powdered clay, the plunger is forced down a short distance under enormous pressure, usually produced by an application of the knee-joint principle. A change in the mold from one shape to another can easily be made, and hence brick of all desired shapes may be molded with regularity and burned almost as rapidly as ordinary brick. Common brick and pavers, particularly the latter, contract and warp to a considerable degree in the kilns. This makes them slightly uneven in size and shape and renders it correspondingly difficult to build a smooth wall with them. But with the dry-pressed brick, because of the small quantity of water used, shrinking and warping are reduced to a minimum; hence the superiority of this brick. For special walls it is necessary to hand sort the brick with reference to perfection of form and color. No matter how uniform the shale appears to be, nor how carefully the firing is done, there will be slight differences in amount of contraction and in shades of color produced. Therefore, when the highest grade is marketed warped specimens must be discarded and the brick "colored" by hand sorting so as to produce a uniform color in the wall.

ROOFING TILE.

A plant for the manufacture of roofing tile, owned by the Western Roofing Tile Company, is operated at Coffeyville. It is situated beside the Missouri Pacific Railway, in the southwestern part of town. It manufactures red tile of ordinary shape and different kinds of fancy-shaped tile of varying colors, as demand or occasion may require. It makes also a great variety of ornamental patterns for cornices, gables, finials, etc., and is well equipped for such work. The clay fortunately burns to a rich, deep, uniform red of pleasing tint. Although this industry dates only from 1903, the company has secured an excellent start and is already shipping roofing tile as far east as St. Louis and as far north as Iowa.

POTTERY.

A large pottery plant, operated by the Coffeyville Pottery and Clay Manufacturing Company, stands at the northeast edge of Coffeyville. It makes stoneware crocks, jars, jugs, etc., and during the greater part of the year 1904 it produced about 40,000 gallons of hollow ware per month, using an average of 4 pounds of clay per gallon. The clay used is the shale member of the Parsons formation.

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SOILS.

The soils of the Independence quadrangle consist, in the main, of two classes, sedentary and transported. The sedentary class includes the soils derived from the underlying or adjacent country rock in place, principally through the agencies of weathering, disintegration, corrasion, etc. A sedentary soil accordingly varies with the nature of the parent rock and with the character and quantity of foreign organic material introduced.

SEDENTARY SOILS.

The soil-producing rocks of the Independence quadrangle, in the order of their importance, are limestone, shale, and sandstone. The limestone soil, though not the most abundant, occupying only about 200 square miles, or less than 22 per cent of the area of the quadrangle, is preeminently the most important. In most cases it is a dark or black heavy soil which greatly excels the other sedentary soils in fertility for nearly all kinds of cultivation and for grazing and dairy purposes, and which is the least susceptible to drought. As an example may be cited the black soil of the Piqua limestone belt, which annually grows heavy crops of corn, wheat, and other products.

Next to the limestone soil in importance is the shale soil, which, since the shale weathers to a clay, is clayey or argillaceous. In the Independence quadrangle it is usually light or buff colored. It is lighter and less productive than the limestone soil, but is more or less extensively cultivated. It varies from place to place, decreasing in fertility with increase in arenaceous material derived from sediments that were deposited along with the shale. Like the sandstone soil, it occupies about 400 square miles, or 40 per cent of the area of the quadrangle.

The least important agriculturally of the sedentary soils is the sandstone soil, derived from sandstone through the processes of disintegration and weathering. It varies from almost pure sand in some localities to sandy clay in others. It is the least fertile and least adapted for agriculture of all the sedentary soils of the quadrangle, but it supports the most important vegetation next to the prairie grass, namely, the native timber growth of the uplands, the black-jack oak (*Quercus nigra*), which, though not a tall or stately tree, forms many timbered areas several miles in extent in the otherwise barren prairie. According to reports of old settlers the timber was far more extensively distributed in early pioneer times, before its limits became greatly reduced by frequent prairie and forest fires. During recent years, however, the timber is, according to reports, everywhere extending its marginal limits and increasing in growth.

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TRANSPORTED SOILS.

The transported soil of the quadrangle is that which has been moved and deposited by water, and is essentially the veneer of alluvium that has been treated under "Geology" (p. 11) and that constitutes the surface deposit of the flood plain of the Verdigris and of the lower reaches of its tributaries. It is the most composite soil of the quadrangle, consisting of particles derived from all the formations occurring within the drainage basins above the points at which it is found, hence much of it has come from distant points outside of the Independence quadrangle—some from the flint hills of Butler County on the west and some from Chase, Lyon, and other counties on the north.

This soil, by reason of its character and geographic position, is commonly known as "made ground," "bottom land," or "bottom." It is usually black and heavy, is a good holder of moisture, and constitutes some of the richest agricultural land of the Mississippi Valley, being unsurpassed in heavy yields of wheat and corn. In some sections it is so heavy, impervious, and tenacious as to be tillable only with great difficulty, and is locally known as "gumbo," but it is not related to the formation to which the term "gumbo" applies in a geologic sense.

It also supports considerable timber, a mixed growth of hard woods locally lining the streams and valleys. Its relatively low elevation and the flatness of the surface it underlies render it less susceptible to drought than the uplands. Unfortunately, during the last three years its immense crops have been almost wholly destroyed by the summer floods, whose duration, volume, and destructiveness have surpassed anything before witnessed in these valleys by the oldest settlers. So great has been the loss occasioned by these floods in the Verdigris, Neosho, and other river valleys in recent years that relief is becoming a very important problem for public solution. This problem is being studied by the State of Kansas and the hydrographic division of the United States Geological Survey, the results of whose investigations indicate that, as the topography is not adapted to water storage, the levee system is the best solution now in sight.

AGRICULTURE.

Except on the uplands and in the rough sandstone country used as pasture land agriculture is carried on throughout the quadrangle, though the recent rapid development of oil and gas has detracted materially from its interest. The principal products are wheat, corn, and hay. Other grains and cotton are also grown and cattle, horses, and mules are raised.

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With the rapid increase in population horticulture near the larger cities and towns has become a profitable pursuit and the fruits and vegetables of similar latitudes and climates are grown without difficulty.

WATER SUPPLY.

FRESH WATER.

STREAMS.

The surface of the Independence quadrangle drains into Verdigris River, whose waters flow southeastward by way of Arkansas and Mississippi rivers into the Gulf of Mexico. The Verdigris flows through the quadrangle a little east of its median line and in a general direction slightly east of south. The three most important cities of the quadrangle, Neodesha, Independence, and Coffeyville, are situated on it. The Verdigris and all its tributaries carry potable water, which fact, taken in connection with its size and large volume of water, renders this stream of primary economic importance. Its average annual run-off, as determined near Liberty by the hydrographic branch of the United States Geological Survey during the eight years from 1896 to 1903, is 0.454 second-foot per square mile, and its average velocity is approximately 1.2 miles per hour.[a]

It heads at an elevation of 1,400 feet about 80 miles northwest of Independence, in the southeastern part of Chase County, about 12 miles southwest of Emporia, and it joins the Arkansas in Indian Territory about 110 miles south of Independence. Its length is 290 miles and the area of its drainage basin about 8,000 square miles. The basin has the shape of an elongated ellipse, whose maximum width, which is about 90 miles, lies near the Kansas–Indian Territory boundary line. The average annual precipitation of the whole basin is 35 to 40 inches; the precipitation for the Independence quadrangle portion is about 44 inches.

The average width of the flood plain of the Verdigris within the limits of the quadrangle is about 2 miles. About 30 feet below the surface of this flood plain the river meanders in short oxbows and broad winding curves; but in times of high water, particularly during the midsummer flood period, it overflows its banks and inundates the flood plain for a width of 1 to 3 miles, with great destruction to crops and property. Its normal width at the State boundary line is about 140 feet. "It is essentially a surface run-off stream; its water is muddy, the flood flow large, the summer flow small, and the fluctuations in height rapid."[b]

It enters the quadrangle on the north at an elevation of about 820 feet and leaves it at 690 feet at the State line on the south, so that in its course of about 50 miles across the quadrangle it has a total fall of

[a] Murphy, E. C., Characteristics of two companion streams of the plains: Eng. News, vol. 53, No. 17, pp. 432–434.
[b] Nineteenth Ann. Rept. U. S. Geol. Survey, pt. 4, 1899, p. 363.

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130 feet, with no local falls nor shoals of importance. This graded course facilitates its use for water-power purposes, examples of which are shown at the McTaggart mill, about 6 miles southeast of Independence, and at the mill at Neodesha. Owing to the cheapness of natural gas for generating power no general use is made of this water power at present.

Between Independence and the McTaggart mill the river is navigable for small steamboats, which are used principally for pleasure transportation between Independence and Brewster Park, situated near the mouth of Drum Creek.

The principal tributaries received by the Verdigris in the quadrangle are Fall and Elk rivers, both from the northwest, where they have their source in the flint hills of Greenwood and Butler counties, respectively. Each is large enough for water-power purposes, Fall River being used for flour-mill power at Neodesha and Elk River supplying power at Elk. Fall River is reported to be less muddy and more steady in flow than the Verdigris and Elk River less steady. Fall River joins the Verdigris in the northern part of the quadrangle about a mile southeast of Neodesha, and Elk River joins it near the middle of the quadrangle 2 miles north of Independence.

Onion Creek, rising 4 miles northwest of Bolton and flowing to the southeast, drains a considerable portion of the south-central part of the quadrangle and joins the Verdigris near the State line. Much of its course lies in a deep, narrow channel confined by mud banks 20 feet high. The southwest corner of the quadrangle is drained by a part of Little Caney Creek, whose main tributary, Bee Creek, rises 5 miles southwest of Elk, near the middle of the western border of the quadrangle, and whose waters, flowing south, leave the quadrangle a mile southwest of Caney and finally reach the Verdigris through Caney River about 45 miles south of the State line.

The tributaries entering the Verdigris from the east and draining the eastern third of the quadrangle, which consists of a belt 5 to 10 miles in width, include no stream as large as those that join it from the west. The more important, named from north to south, are Chetopa, Dry, Drum, Big Hill, Claymore, and Pumpkin creeks, of which the largest are Big Hill, Pumpkin, and Drum creeks, 35, 32, and 25 miles long, respectively. Chetopa Creek, rising in the country southwest of Thayer, near the northeast corner of the quadrangle, takes a nearly westward course and enters the Verdigris about a mile north of Neodesha.

Drum Creek rises about 4 miles north of Morehead in the Parsons quadrangle, whence its course is a little west of south past Cherryvale to the Verdigris, which it joins 4 miles southwest of Independence. It contains considerable water for a stream of its length, long stretches of it being sluggish.

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Big Hill Creek has its source 4 miles northeast of Morehead. Its course is west of south past Liberty, about parallel with that of Drum Creek. It joins the Verdigris a mile north of Coffeyville and is the longest of its eastern tributaries.

Pumpkin Creek heads in the Parsons quadrangle about 22 miles northeast of Coffeyville. Only about 5 miles of its course lie in the Independence quadrangle.

Neodesha, Independence, and Coffeyville procure their water supplies from Verdigris River. The Independence pumping station is located on the west bank of the river, just east of the city, whence the city mains are fed with adequate pressure. The Coffeyville pumping plant is also located on the west bank of the river at the base of Reservoir Hill, 1½ miles northeast of Coffeyville. Here the water is pumped from the river into a large reservoir at the top of the hill, 210 feet above the river, whence it enters the city mains.

SPRINGS.

At a number of points within the limits of the quadrangle water of good quality, issuing from beneath the surface soil and gravel at the bases of hills and in the sides or heads of valleys, is used for stock and domestic purposes, such sources being locally known as springs. No deep-seated springs, however, having their source in bed rock, were noted in the course of this work.

WELLS.

The wells most commonly in use throughout the quadrangle are shallow, supplying, as a rule, surface water only, which, owing to the soluble salts or mineral matter contained in the rocks, particularly the shale through which it percolates, is usually hard, alkaline, or brackish. Exceptions occur where the wells are in sandstone, which usually yields good potable water, frequently soft, and also in many of the lowland regions where the water has become purified by filtering through the alluvial deposits of silt, sand, and gravel.

Since the shallow wells may fail in dry seasons, deep wells have been drilled to insure a permanent supply of water, especially in parts of the uplands; but the water of these wells is, like that of the shallow wells, usually hard. In fact, beyond a certain point the deeper the well is drilled, as shown by numerous deep gas and oil borings all over the quadrangle, the more likely is its water to be brackish or saline.

CISTERNS.

Both in towns and in rural districts cisterns furnish a considerable portion of the most palatable and wholesome water of the quadrangle. They are inexpensive, owing to the cheapness of local brick and cement.

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POOLS.

A considerable part of the water for stock on the farms and ranches of the quadrangle, particularly in the uplands, is supplied by the pioneer method of impounding the run-off rain water in earth reservoirs, ponds, or basins, by means of artificial dams across draws and ravines. Such a basin, being dependent on the rainfall for its supply, is usually built large enough to hold sufficient water to last from rain to rain or throughout a considerable portion of the summer season. As a rule the larger the pond the better the quality of the water. Shale formations and their resultant clay soil by reason of their impervious character are particularly favorable for impounding waters, as is also limestone and its heavy dense soil; but sandstone formations and soils, on account of their porosity, are not adapted for the purpose.

MINERAL WATERS.

The waters under this head include the mineral wells or springs at Independence, Coffeyville, and Cherryvale. The following is the substance of a report of the University Geological Survey of Kansas on these waters.[a]

BROMO-MAGNESIUM WELL, INDEPENDENCE.

In 1884 a well 1,100 feet deep was bored in the northern part of Independence, the tubing of which extend 400 feet below the surface, and a pipe used for drawing the water extends several hundred feet farther down. The well is artesian in character. A small stream flows from it most of the time.

A sanitarium and bath hotel have been erected here with facilities for using the brine either directly or mixed with fresh water. The water is raised to the surface by a windmill. As shown in the analysis given below, the water contains a comparatively large quantity of bromides. It is the first water of its kind discovered in this region, though other waters have been found recently that contain bromides and iodides. This water compares with other well-known mineral waters as follows:

Comparison of bromo-magnesium (Independence, Kans.) water with other mineral waters.[a]

	Fabian, N. Y.	Hawthorne, Saratoga.	Congress, Saratoga.	Dead Sea.	Bromo-magnesium well.
Sodium bromide (NaBr)	4.655	1.534	8.559	156.53	13.711
Sodium odide (KI)	.235	.198	.138	Trace.	.092

[a] Univ. Geol. Survey Kansas, vol. 7, 1902, p. 149.

This water is somewhat similar in composition to the water of the Atlantic Ocean, though it contains a larger quantity of calcium salts, twice as much magnesium, more sodium iodide, and nearly one-half

[a] Mineral waters: Univ. Geol. Survey, Kansas, vol. 7, 1902, pp. 128–320.

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as much sodium bromide; and its mineral strength is about twice as great as that of ocean water, as may be seen from the following analysis:

Analysis of water of bromo-magnesium well, Independence, Kans.[a]

IONS.	Grams per liter.	RADICALS.	Grams per liter.
Sodium (Na)	23.4678	Sodium oxide (Na_2O)	31.6278
Potassium (K)	.1060	Potassium oxide (K_2O)	.1279
Calcium (Ca)	2.7620	Calcium oxide (CaO)	3.8710
Magnesium (Mg)	1.5095	Magnesium oxide (MgO)	2.5159
Iron (Fe)	.0090	Iron oxide (FeO)	.0117
Aluminum (Al)	Trace.	Aluminum oxide (Al_2O_3)	Trace.
Chlorine (Cl)	45.0811	Chlorine (Cl)	45.0811
Bromine (Br)	.1826	Bromine (Br)	.1826
Iodine (I)	.0013	Iodine (I)	.0013
Sulphuric acid ion (SO_4)	.2395	Sulphuric anhydride (SO_3)	.1995
Silicic acid ion (SiO_3)	.0251	Silicic anhydride (SiO_2)	.0198
		Organic matter	Trace.
		Carbonic anhydride (CO_2)	.2998
		Water (H_2O)	.0610
			83.9994
		Less oxygen equivalent	10.1993
			73.8001

HYPOTHETICAL COMBINATION.

	Grams per liter.	Grains per gallon.
Sodium chloride (NaCl)	59.4476	3,472.433
Sodium bromide (NaBr)	.2351	13.733
Sodium iodide (NaI)	.0016	.093
Potassium sulphate (K_2SO_4)	.2361	13.793
Calcium chloride ($CaCl_2$)	7.1872	419.806
Calcium sulphate ($CaSO_4$)	.1551	9.061
Calcium bicarbonate ($CaH_2(CO_3)_2$)	.5236	30.586
Magnesium chloride ($MgCl_2$)	5.9651	348.323
Iron bicarbonate ($FeH_2(CO_3)_2$)	.0289	1.684
Alumina (Al_2O_3)	Trace.	Trace.
Silica (SiO_2)	.0198	1.157
Organic matter	Trace.	Trace.
	73.8001	4,310.669

Specific gravity, 1.052. Temperature, 16.6° C. (62° F.). Analyst, E. H. S. Bailey.

COFFEYVILLE MINERAL WELL.

The Coffeyville mineral well is situated on the Joseph Kloehr property 1½ miles east of Coffeyville, in the Verdigris River bottom, a quarter of a mile from the river. It is reached by a driveway leading from the main road to a two-story building arranged as a water-cure establishment for the accommodation of boarders. The water is also sold to people in the community. The heavy timber of the vicinity adds much to the attractiveness of the situation. The well is dug 16 feet deep and from the bottom of the excavation a pipe is driven 16 feet and 8 inches downward into the sand and gravel. The analysis of the water is as follows:

[a] Univ. Geol. Survey Kansas, vol. 7, 1902, p. 150.

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Analysis of water from Coffeyville mineral well, Kansas.[a]

IONS.	Grams per liter.
Sodium (Na)	0.0088
Calcium (Ca)	.1661
Magnesium (Mg)	.0357
Iron (Fe)	.0095
Chlorine (Cl)	.0135
Sulphuric acid ion (SO_4)	.0276
Silicic acid ion (SiO_3)	.0304

RADICALS.	Grams per liter.
Sodium oxide (Na_2O)	0.0118
Calcium oxide (CaO)	.2325
Magnesium oxide (MgO)	.0595
Iron oxide (FeO)	.0122
Chlorine (Cl)	.0135
Sulphuric anhydride (SO_3)	.0230
Silicic anhydride (SiO_2)	.0240
Carbonic anhydride (CO_2)	.4859
Water (H_2O)	.0993
	.9617
Less oxygen equivalent	.0031
	.9586

HYPOTHETICAL COMBINATION.

	Grams per liter.	Grains per gallon.
Sodium chloride (NaCl)	0.0223	1.304
Calcium sulphate ($CaSO_4$)	.0391	2.282
Calcium bicarbonate ($CaH_2(CO_3)_2$)	.6259	36.559
Magnesium bicarbonate ($MgH_2(CO_3)_2$)	.2172	12.686
Iron bicarbonate ($FeH_2(CO_3)_2$)	.0301	1.755
Silica (SiO_2)	.0240	1.405
	.9586	55.991

Analyst, E. H. S. Bailey.

CHERRYVALE MINERAL WELL.

The Cherryvale mineral well belongs to the bicarbonate group of mineral waters. It is bored about 3 miles northwest of Cherryvale near Drum Creek. The water is said to come from a depth of about 120 feet. A partial analysis of a sample received from Dr. M. A. Findley, of Cherryvale, has been made, with the following result:

Analysis of water from Cherryvale mineral well, Kansas.[b]

IONS.	Grams per liter.
Sodium (Na)	0.5910
Calcium (Ca)	.0098
Magnesium (Mg)	.0114
Iron (Fe)	.0031
Chlorine (Cl)	.5330
Silicic acid ion (SiO_3)	.0148

RADICALS.	Grams per liter.
Sodium oxide (Na_2O)	0.7966
Calcium oxide (CaO)	.0138
Magnesium oxide (MgO)	.0190
Iron oxide (FeO)	.0040
Chlorine (Cl)	.5330
Silicic anhydride (SiO_2)	.0117
Carbonic anhydride (CO_2)	.5328
Water (H_2O)	.1093
	2.0202
Less oxygen equivalent	.1210
	1.8992

[a] Univ. Geol. Survey Kansas, vol. 7, 1902, p. 232. [b] Idem, pp. 248-249.

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HYPOTHETICAL COMBINATION.

	Grams per liter.	Grains per gallon.
Sodium chloride	0.8810	51.459
Sodium bicarbonate	.8870	51.804
Calcium bicarbonate	.0405	2.388
Magnesium bicarbonate	.0690	4.024
Iron bicarbonate	.0100	.584
Silica	.0117	.684
	1.8992	110.943

Analysts, E. H. S. Bailey and D. F. McFarland.

PARKHURST IRON SPRING, INDEPENDENCE.

There is an iron spring on the Parkhurst estate, about 60 feet above the water, on the right bank of Verdigris River, about 1½ miles northeast of Independence. The river is here lined with native timber and presents a pleasing, diversified view; just east of Independence it is navigable for small steamboats and other light craft.

The spring flows from beneath a sandstone bed, and the water deposits much iron after it comes in contact with the air. The flow in the driest weather is about 60 gallons per hour. The analysis of the water is as follows:

Analysis of water from the Parkhurst iron spring, Independence, Kans.[a]

IONS.

	Grams per liter.
Sodium (Na)	0.0725
Calcium (Ca)	.3735
Magnesium (Mg)	.1668
Manganese (Mn)	.0018
Iron (Fe)	.0101
Sulphuric acid ion (SO_4)	19.9545
Silicic acid ion (SiO_3)	.0501

RADICALS.

	Grams per liter.
Sodium oxide (Na_2O)	0.0955
Calcium oxide (CaO)	.5231
Magnesium oxide (MgO)	.2784
Manganese oxide (MnO)	.0021
Iron oxide (FeO)	.1325
Sulphuric anhydride (SO_3)	1.6718
Carbonic anhydride (CO_2)	.1716
Hydrogen sulphide (H_2S)	.0014
Silica (SiO_2)	.0393
	2.9157

HYPOTHETICAL COMBINATION.

	Grams per liter.	Grains per gallon.
Sodium sulphate (Na_2SO_4)	0.2187	12.774
Calcium sulphate ($CaSO_4$)	1.5148	88.479
Magnesium sulphate ($MgSO_4$)	.8352	48.784
Manganese bicarbonate ($MnH_2(CO_3)_2$)	.0046	.271
Iron bicarbonate ($FeH_2(CO_{32})$	.2952	17.244
Silica (SiO_2)	.0393	2.299
Carbonic anhydride (CO_2)	.0063	.373
Hydrogen sulphide (H_2S)	.0014	.083
Chlorine, potassium, and lithium	Traces.	Traces.
	2.9155	170.307

Analyst, Paul Schweitzer.

As to the geologic source of these mineral waters, the statement by Prof. W. R. Crane, in the report cited, may be quoted:[b]

The Independence bromo-magnesian well extends through both Upper and Lower Carboniferous and derives its water from either the sub-Carboniferous or lower Silurian.

The Coffeyville well and the Parkhurst spring lie wholly within the Upper Carboniferous strata.

[a] Univ. Geol. Survey Kansas, vol. 7, 1902, pp. 286, 289. [b] Idem, p. 325.

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